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# COMET INTERCEPT STUDY

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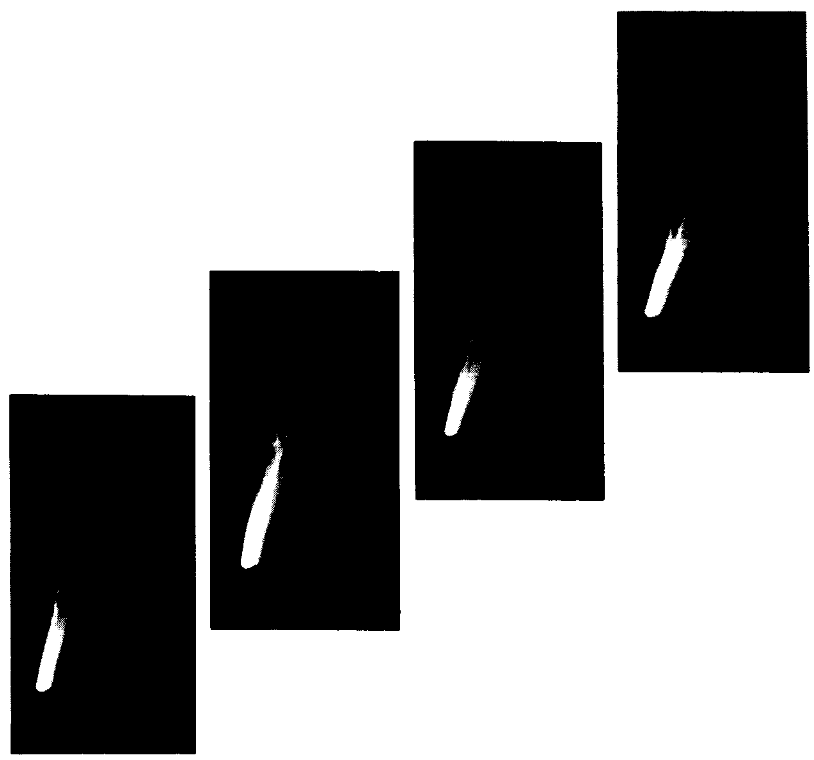

SPACE TECHNOLOGY LABORATORIES, INC.
*a subsidiary of Thompson Ramo Wooldridge Inc.*
ONE SPACE PARK • REDONDO BEACH, CALIFORNIA

# COMET INTERCEPT STUDY

# FINAL REPORT

**NASw-414**

8668-6002-RU-000

**28 MARCH 1963**

SPACE TECHNOLOGY LABORATORIES, INC.
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ILLUSTRATIONS (Continued)



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# I. INTRODUCTION

STL has been studying, during the past year, the problems of carrying out a comet intercept mission. During the course of this study, the properties of 31 short-term comets have been examined to determine the feasibility of a mission to any of them during the next 15 years. In the process of selecting these comets, injection energies for each of these comets at a suitable launch period were determined. In addition, the distance of the earth at intercept, the transit and flight times, and the guidance requirements were evaluated. Also, to determine the effectiveness of such a mission, possible scientific instruments which could be used to measure the various characteristics of the comets have been studied. Finally, to determine the present feasibility of such a mission, the payload capability of available boosters was examined, and a spacecraft configuration with appropriate subsystems was also studied.

The origin of the name "comets," given to bright and extended objects occasionally observed in the sky, must be traced to the earliest historians who recorded their appearances. Being wholly unlike other astronomical bodies because of their apparent angular motion, their rapid changes in shape and brightness and the apparent irregularity of their apparitions, comets always were an attractive subject for speculation. Their study from a modern scientific point of view started when Halley explained the motion of the comet carrying his name on the basis of Newtonian mechanics. The subsequent development of cometary dynamics established that all comets are members of the solar system, although some of them may have elliptical orbits with major semiaxes of $10^5$ AU, with inclinations and directions of perihelia nearly at random. The extent of the solar system appears, thus, to be far larger than the domain occupied by the planets would indicate, and the only sources of information about such remote vastness of the solar "sphere of action" are the comets. Not all comets have nearly parabolic orbits, however. When a highly elliptical comet approaches the inner regions of the solar system along a random orbit, there is a small but finite probability that its motion will be strongly perturbed by Jupiter, becoming "captured" into an orbit with a period of a few or a few tens of years. Such is believed to be the origin of about 100 short-period comets known at present, which in general are fainter than the sporadic, nearly parabolic ones.

The light in which all comets are observed derives from the sun, either by scattering, or by induced fluorescence. In a typical comet the scattered radiation arises mainly in the nucleus, a bright source of small angular dimension which is believed to be an aggregate of solid matter with an effective cross section for scattering around 100 $km^2$. The coma, a more or less tenuous envelope of the nucleus extending $10^4$ - $10^5$ km around it, also contains solid particles inmersed in a gas characterized by resonant emissions of $C_2$, $C_3$, $NH_2$, CN, and other molecules. The outer parts of the coma blend in the antisolar direction with the tail, an elongated feature with filamentary structure characterized by the emission of $CO^+$ and $N_2^+$ molecules together with varying amounts of dust particles. The dimensions of the tails vary greatly from object to object. Nearly parabolic objects have been observed with tails more than one astronomical unit in length. At the other extreme, Schwassmann-Wachmann I, a comet of the Jupiter family with small eccentricity, at certain epochs has the appearance of an asteroid, without detectable tail or coma.

An understanding of the complex physical processes taking place in a comet as result of the interaction of cometary matter with the solar corpuscular and electromagnetic radiation, and with the interplanetary magnetic field, is far from being complete. It would be more proper to say that just a beginning has been made in this direction. It is for this reason that the question of inquiring into the practical possibility of probing a comet, in order to make on-the-spot measurements, is of actual interest.

The general conclusion of this study is that a mission to a comet is completely feasible and could be carried out in the very near future. A booster consisting of the Atlas-Agena with a solid propellant third stage could inject a satisfactory spacecraft to intercept any one of a number of comets. A simple, spin-stabilized spacecraft, with a technique which can change the direction of the spin vector of the spacecraft, would permit the spacecraft to have a constant attitude with respect to the sun, allowing excellent solar-cell power-supply characteristics and excellent thermal control characteristics. More importantly, it would allow the use of a fan-beam antenna which would have a 13-db gain over an omnidirectional antenna. This system can assure a very satisfactory information rate from the scientific experiments during intercept. In addition, such a spacecraft would be a useful interplanetary explorer before and after intercept.

The single important problem remaining appears to be the accurate determination of the orbit of the comet. Although a great deal of work has been carried out to determine comet orbits, the orbit accuracy of even the best-known comets, such as Encke, is insufficient to assure a suitable intercept. Our evaluation of the types of scientific instruments to be carried indicates that the spacecraft should pass at a distance from the nucleus which is about 40 percent of the coma diameter. And as a rule of thumb, we have assumed that the comet diameter is 100,000 km and thus the spacecraft should pass within 10,000 km of the nucleus. At present, the position and velocity of a comet are not known well enough to assure such a small miss. However, STL performed a comet tracking analysis and determined that if the position of the comet were measured for 8 months prior to intercept, its position and velocity would be known to 10,000 km, $1\sigma$. This analysis assumed 1 measurement per week to assure a different sky background and that each observation was accurate to 2 seconds of arc. Our experience indicates that even a great many more measurements will not substantially increase the accuracy of the orbit determination. Therefore, it appears that in order to assure a high probability of intercept at the right distance from the nucleus, the accuracy of the angular positions of the chosen comet should be improved at least by a factor of 3. The fundamental limitation in the reliability of cometary positions at present arises from the uncertainties in the reference stars to which comet positions are generally referred (Astrographic Catalogue). However, on the basis of modern photographic material as currently used in the revision of the AG Catalogues, it would not be an unduly extensive or costly task to relate the position of a number of stars along the comet's path to the $FK3_2$ or other fundamental system. The possibility of carrying out such a program was demonstrated in the much more extensive 1930-Eros campaign that lead to the determination of the solar parallax. Therefore, it appears that a mission to specific comets is feasible and sensible within a few years.

This final report is divided into four basic sections: Section II sets the background for the rest of the report, describing the comets and their orbits. Section III describes the physics of comets and the types of experiments which would be appropriate for a comet intercept mission. Section IV describes both the general requirements for an intercept mission, i.e., the properties, the injection energies required, the transmission distance at intercept, the closing velocity of the comet and the spacecraft, and typical kinds of misses to be expected for the comets. It also includes a discussion of the accuracy required, the general spacecraft characteristics, the booster vehicle capabilities, launch logistics, and reliability. In addition, Section IV also includes a separate page of figures giving the intercept characteristics for each of the comets studied in detail. Section V contains a brief analysis of a specific intercept mission to the comet Encke, the type of spacecraft and circumstances, and a specific intercept trajectory.

## II. THE COMETS AND THEIR ORBITS

The first step in our comet study was to examine all short-term comets, with periods less than 20 years, that make an appearance between 1963 and 1977. Thirty-one comets fall within this category; the elements, periods, and future apparition dates of these comets are given in Table 2-1. All of these comets rotate counter-clockwise, and all, except Borrelly, Tuttle, and Giacobini-Zinner have inclinations less than 22 degrees. All, except Neujmin (1), Tempel-Tuttle, and Westphal, have periods less than 15 years and most have periods of less than 9 years. The source of the data for this table is J. G. Porter's Catalogue of Cometary Orbits, 1960, and Memoirs of the British Astronomical Association, Vol. 39, No. 3, June 1961.

To give the trajectory specialist a feeling for the properties of these comets, the orbit of each comet has been drawn showing all of the major orbital elements. The vernal equinox was fixed in each drawing to provide a uniform orientation with respect to the solar system. A second drawing is also presented showing the apparent motion of each comet for $\pm$ 100 days from perihelion as seen from the earth. The position of the earth on the day of a few perihelion passages is shown so that the conditions for observation of the comet can be visualized. Subsequent earth-comet relationships are indicated by the perihelion position of the earth at that time. Since the earth is fixed, the comet appears to move in a clockwise direction rather than counter-clockwise as it would appear inertially. Since the earth moves about the sun approximately 1 degree per day, an error in time of perihelion passage of a day can be compensated for by simply moving the position of the earth through an appropriate angle. In this figure, the comet trajectory is projected onto the plane of the ecliptic rather than rotated onto the ecliptic, and hence, the effect of the out-of-plane component is not shown. These two figures can allow us to get a physical understanding of the path of the comet about the sun with respect to the earth, and are useful in understanding the intercept trajectory problems discussed in Section IV.

A third figure showing an observed arc of recent passages of the comets is also given. This figure, coupled with the apparent path figure, will allow us to understand the sighting problems which are very important in determining the comet orbit because, as discussed in Section IV, the accuracy with which we know the orbit of any given comet before its reappearance is

Table 2-1. Geometrical Elements and Periods of 31 Comets

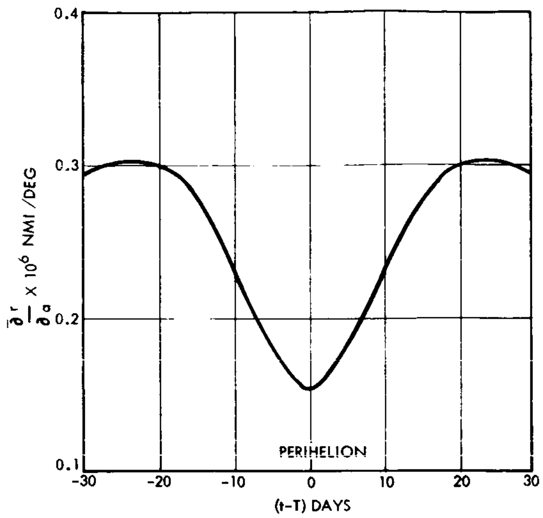
| | SEMI-MAJOR AXIS $a$ (AU) | PERIHELION DISTANCE $q$ (AU) | APHELION DISTANCE $Q$ (AU) | ECCENTRICITY $e$ | ARGUMENT OF PERIHELION $\omega$ (degrees from ascending node) | LONGITUDE OF ASCENDING NODE $\Omega$ (degrees from vernal equinox) | INCLINATION (DEGREES FROM PLANE OF ECLIPTIC) $i$ (degrees from plane of | POLAR DISTANCE FROM THE ECLIPTIC AT PERIHELION (X $10^6$ NMI) | HELIOCENTRIC DISTANCE TO THE INNERMOST NODE $r_n$ (AU) | PERIOD OF THE MOST RECENT ORBIT $P$ YEARS | NOMINAL PERIHELIA OF THE NEXT SUCCEEDING PASSAGES THROUGH 1977 $T_1$ | $T_2$ | $T_3$ | $T_4$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ENCKE | 2.21 | 0.339 | 4.09 | 0.847 | 185.2 | 334.7 | 12.4 | 0.56469 | 0.339 | 3.30 | 1964 MAY 26 | 1967 SEP 12 | 1970 DEC 31 | 1974 APR 19 |
| GRIGG-SKJELLERUP | 2.87 | 0.855 | 4.88 | 0.704 | 356.3 | 215.4 | 17.6 | 1.21005 | 0.850 | 4.90 | 1961 DEC 31 | 1966 NOV 24 | 1971 OCT 19 | 1976 SEP 13 |
| HONDA-MRKOS-PAJDUSAKOVA | 3.01 | 0.556 | 5.46 | 0.815 | 184.1 | 233.1 | 13.2 | 0.72603 | 0.557 | 5.21 | | 1964 JUL 9 | 1969 SEP 24 | 1974 DEC 10 |
| TEMPEL (2) | 3.02 | 1.369 | 4.68 | 0.548 | 191.0 | 119.3 | 12.5 | 4.51752 | 1.376 | 5.27 | 1962 MAY 15* | 1967 AUG 18 | 1972 NOV 22 | |
| TUTTLE-GIACOBINI-KRESAK | 3.11 | 1.117 | 5.10 | 0.641 | 37.9 | 165.6 | 13.8 | 13.22988 | 1.216 | 5.48 | | 1962 APR 23* | 1967 OCT 19 | 1973 APR 13 |
| PONS-WINNECKE | 3.35 | 1.161 | 5.53 | 0.653 | 170.2 | 94.4 | 21.7 | 5.56623 | 1.168 | 6.12 | | 1964 FEB 20 | 1970 JUL 9 | 1976 OCT 25 |
| KOPFF | 3.42 | 1.516 | 5.32 | 0.556 | 161.7 | 121.0 | 4.7 | 3.22680 | 1.546 | 6.32 | 1964 MAY 15 | 1970 SEP 7 | 1977 DEC 30 | |
| GIACOBINI-ZINNER | 3.45 | 0.936 | 5.97 | 0.729 | 172.8 | 196.0 | 30.9 | 5.24355 | 0.939 | 6.42 | 1966 MAR 27 | 1972 AUG 26 | | |
| FORBES | 3.45 | 1.545 | 5.36 | 0.553 | 259.7 | 25.4 | 4.6 | 9.84174 | 2.181 | 6.42 | | 1961 JUL 24 | 1967 DEC 21 | 1974 MAY 23 |
| PERRINE-MRKOS | 3.47 | 1.154 | 5.79 | 0.667 | 167.8 | 242.6 | 15.9 | 5.64690 | 1.167 | 6.47 | 1962 MAR 17* | 1968 SEP 2 | 1975 FEB 19 | |
| WOLF-HARRINGTON | 3.49 | 1.604 | 5.37 | 0.540 | 187.0 | 254.2 | 18.5 | 5.00154 | 1.608 | 6.51 | 1965 FEB 13 | 1971 AUG 19 | | |
| SCHWASSMANN-WACHMANN (2) | 3.49 | 2.157 | 4.83 | 0.383 | 357.7 | 126.0 | 3.7 | 0.48402 | 2.156 | 6.53 | 1968 MAR 18 | 1974 SEP 29 | | |
| DANIEL | 3.54 | 1.465 | 5.62 | 0.586 | 7.3 | 69.7 | 19.7 | 5.08221 | 1.471 | 6.66 | MISSED IN 1957 | 1963 DEC 16 | 1970 AUG 18 | 1977 APR 17 |
| WIRTANEN | 3.54 | 1.618 | 5.47 | 0.543 | 343.5 | 86.5 | 13.4 | 8.55102 | 1.643 | 6.67 | 1967 DEC 15 | 1974 AUG 16 | | |
| D'ARREST | 3.55 | 1.378 | 5.73 | 0.612 | 174.4 | 143.6 | 18.1 | 3.22680 | 1.381 | 6.70 | 1967 JUN 17 | 1963 OCT 30 | 1970 JUL 11 | 1977 MAR 23 |
| AREND-RIGAUX | 3.56 | 1.385 | 5.73 | 0.611 | 326.4 | 124.6 | 17.2 | 18.15075 | 1.478 | 6.71 | 1964 MAY 26 | 1971 FEB 9 | 1977 OCT 27 | |
| REINMUTH (2) | 3.56 | 1.933 | 5.18 | 0.457 | 45.5 | 296.2 | 7.0 | 13.55256 | 2.131 | 6.71 | 1967 AUG 11 | 1974 APR 27 | | |
| BROOKS (2) | 3.56 | 1.763 | 5.36 | 0.505 | 197.1 | 176.9 | 5.6 | 4.03350 | 1.789 | 6.72 | 1967 MAR 8 | 1973 NOV 26 | | |
| HARRINGTON (2) | 3.59 | 1.582 | 5.60 | 0.559 | 232.8 | 119.2 | 8.7 | 15.32730 | 1.845 | 6.80 | 1967 APR 18 | 1974 FEB 4 | | |
| FINLAY | 3.62 | 1.077 | 6.17 | 0.703 | 321.6 | 42.1 | 3.6 | 3.22680 | 1.182 | 6.90 | 1967 JUL 25 | 1974 JUN 17 | | |
| BORRELLY | 3.67 | 1.452 | 5.88 | 0.604 | 350.8 | 76.2 | 31.1 | 10.32576 | 1.459 | 7.02 | 1967 JUN 20 | 1974 JUN 28 | | |
| FAYE | 3.80 | 1.652 | 5.95 | 0.565 | 200.6 | 206.3 | 10.6 | 8.55102 | 1.692 | 7.41 | 1962 JUL 31* | 1969 DEC 29 | 1977 MAY 28 | |
| REINMUTH (1) | 3.88 | 2.026 | 5.74 | 0.478 | 12.9 | 123.6 | 8.4 | 5.40489 | 2.044 | 7.65 | 1965 NOV 17 | 1973 JUL 14 | | |
| AREND | 3.93 | 1.832 | 6.03 | 0.534 | 44.5 | 357.6 | 21.7 | 37.91490 | 2.035 | 7.79 | 1967 JUN 17 | 1975 APR 2 | | |
| SCHAUMASSE | 4.06 | 1.196 | 6.92 | 0.705 | 52.0 | 86.2 | 12.0 | 15.73065 | 1.423 | 8.18 | 1968 JUN 22 | 1976 AUG 27 | | |
| COMAS-SOLA | 4.19 | 1.777 | 6.61 | 0.576 | 40.0 | 62.8 | 13.4 | 21.37755 | 1.944 | 8.59 | 1969 NOV 4 | | | |
| VÄISÄLÄ (1) | 4.78 | 1.741 | 7.82 | 0.636 | 44.4 | 135.4 | 11.3 | 19.28013 | 1.957 | 10.46 | 1970 OCT 25 | | | |
| NEUJMIN (3) | 4.93 | 2.032 | 0.588 | 7.83 | 144.8 | 156.2 | 3.8 | 6.37293 | 2.179 | 10.95 | 1962 MAY 8 + | | | |
| GALE | 4.94 | 1.183 | 8.70 | 0.761 | 209.1 | 67.3 | 11.7 | 9.43839 | 1.249 | 10.99 | | | | |
| TUTTLE | 5.70 | 1.022 | 10.38 | 0.821 | 207.0 | 269.8 | 54.7 | 29.84790 | 1.073 | 13.61 | 1967 JAN 26 | | | |
| NEUJMIN (1) | 6.86 | 1.547 | 12.17 | 0.774 | 346.7 | 347.2 | 15.0 | 7.58298 | 1.568 | 17.95 | 1966 DEC 5 | | | |

not sufficiently high to warrant launching. Therefore, we will want to sight the comet and recompute the precise trajectory before launching.

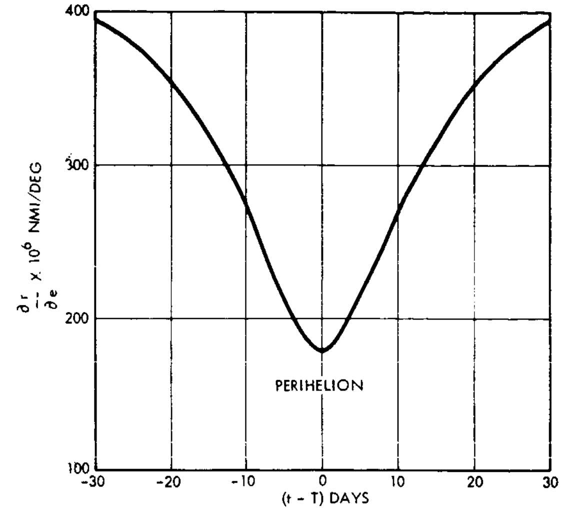
A precise knowledge of the position and velocity of the comet at any time is necessary not only for scheduling the booster vehicle and determining launch windows, but as an essential requirement for midcourse fuel capabilities and thus payload sizing, to evaluate problems, to establish visibility constraints, and to take care of all requirements associated with the launch logistics. The effects of errors in the six elements are shown in Figure 2-1. As can be seen, the effect of errors are generally smallest near perihelion and indeed go to 0 for an error in inclination at perihelion, since in this case the node and perihelion are almost at the same point. However, the effect of an error in time at perihelion passage is largest at the perihelion point and can have an effect of as much as 37 nmi/sec error in prediction. Since for many comets an error in time of perihelion passage of 1 day is not unusual, this could result in a miss of about 3 million nmi. The largest source of error might be in the determination of the orbit eccentricity, which could give us an error between 1,000 and 2,000 nmi per second of degree error. It should be emphasized that these partial derivatives do not convert directly into actual miss for a mission to a comet, since only those components which are perpendicular to the relative velocity vector of comet and spacecraft lead to actual miss. Thus, these partial derivatives provide only upper bounds to the actual miss. This is discussed in greater detail in the guidance section, IV, 2.

As we discuss later in Section IV, the accuracy to which we know an orbit of a comet is one of the key problems in establishing the feasibility of a comet mission. Presently, a considerable effort is being carried on throughout the world to determine comet orbits to greater accuracy than is now available; nevertheless an error of a day in time of perihelion passage is not uncommon. Therefore, the following recommendations are made with respect to observing comets in the event that a comet mission is planned.

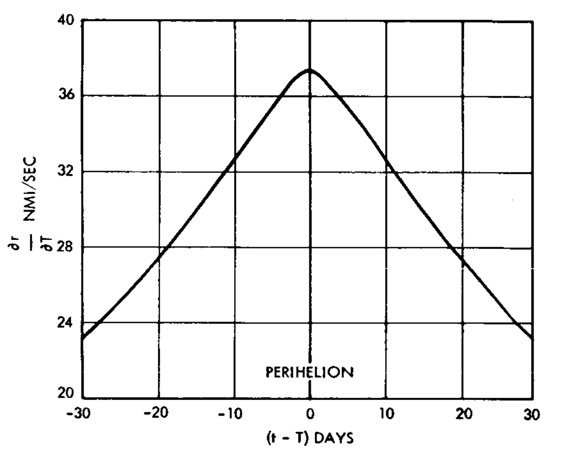
First, a concerted effort should be made to improve the accuracy of the orbit determination for the comet selected. This requires that a considerable number of observatories concentrate on the selected comet to avoid the local effects of weather and to satisfactorily schedule telescope time.



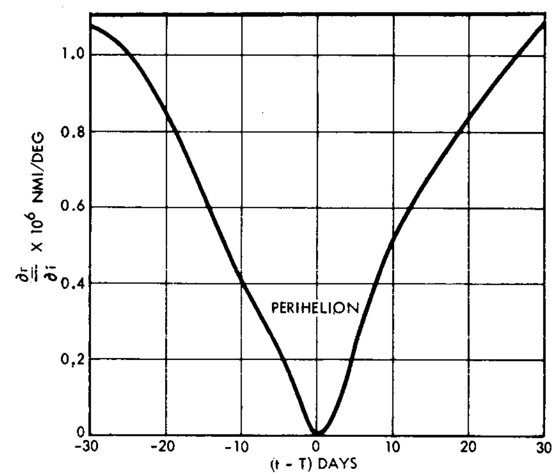

Error in Semi-Major Axis



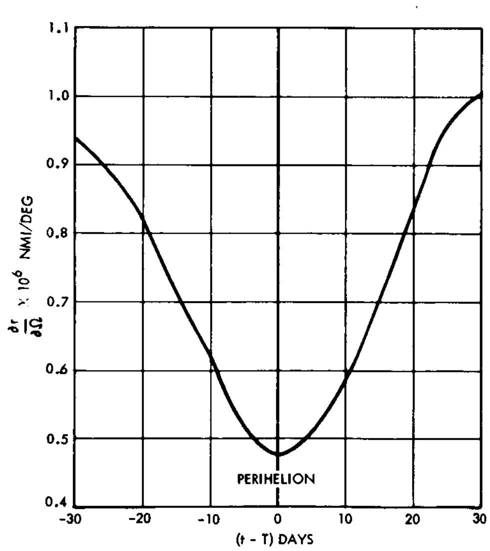

Error in Eccentricity



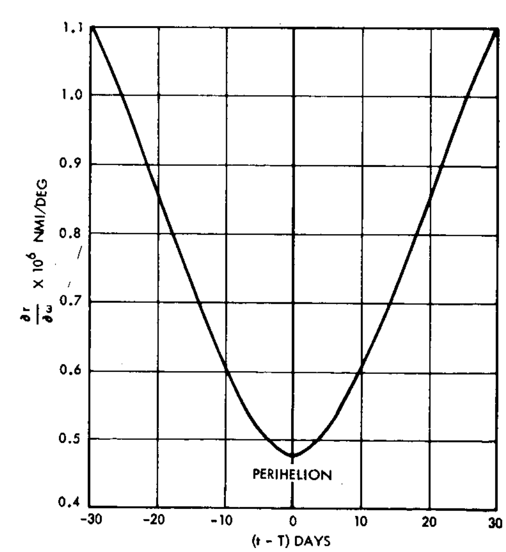

Error in Time of Perihelion Passage




Error in Inclination




Error in Position of Nodes



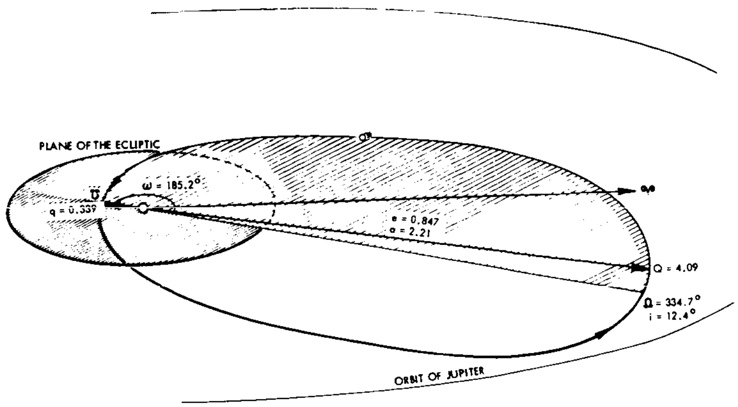

Error in Argument of Perihelion

Figure 2-1. Miss Sensitivities Near Perihelion for Comet Encke

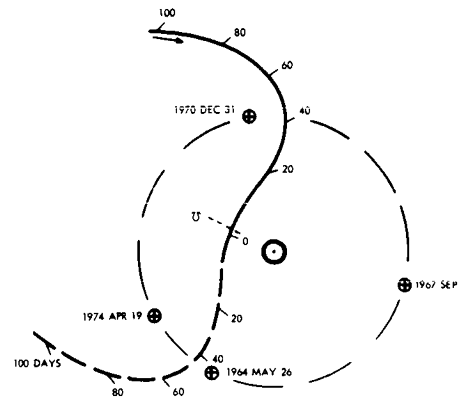
Secondly, such an effort should be coordinated by a central astronomical group who can establish effective and computable techniques which all of the assigned observatories can use. If such a program were carried on, even though very briefly, it is expected that the errors in the elements of the comet could be made almost negligible. Another factor which must also be considered is the baseline to be used for positioning the comet, that is, the fundamental star catalogues. Since much of present astronomy is devoted to astrophysics rather than astrometrics, the fundamental star catalogues have not been kept up-to-date for all regions of the sky. Thus, it is possible that some of the errors in the ascension and declination of a comet are due simply to errors in the fundamental catalogues, and it may be necessary to reduce the effect of these biases. With such an overall program carried on at a central location, utilizing a large computer, the effects of all perturbations can be readily calculated. For example, in the course of this study the comet Encke was integrated with two apparitions, using elements by S. G. Mackover, in a little more than four minutes and included the perturbations by the six planets Mercury to Saturn. A copy of the computation is appended to this report.

Some of the intercept problems resulting from the physical characteristics of the comet orbit and the earth-comet relationship are discussed. An important consideration is flight time which determines the spacecraft lifetime. Flight time is dependent upon the injection velocity, and both depend upon the relative location of the earth at launch time and the comet at intercept. In general, since we must launch in the direction of the earth's motions to make effective use of the earth's velocity and hence reduce our injection velocity requirements, good transit orbits occur when position of the earth is such that a launch along its trajectory will carry us out across the comet trajectory easily. For convenience, comets which go inside the earth's orbit are called "Venus-type comets" and those which go outside, "Mars-type".

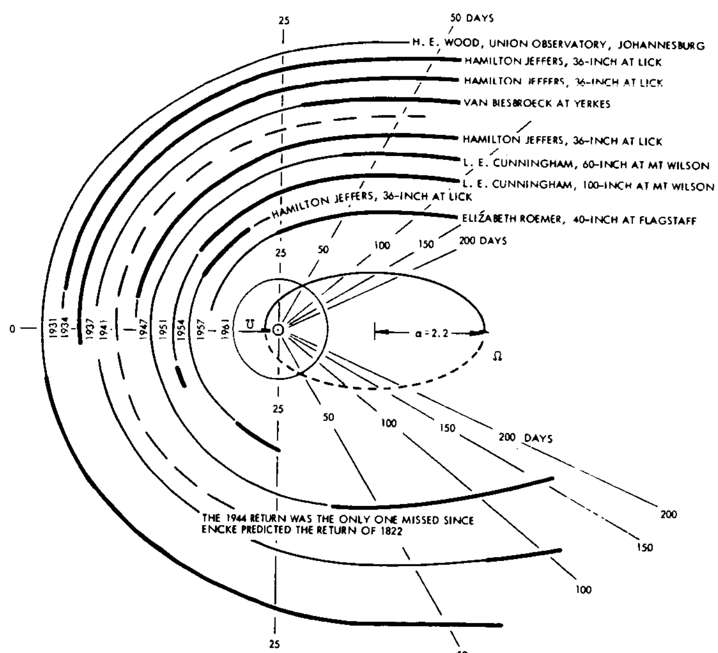
# ENCKE




Orbit of the Comet



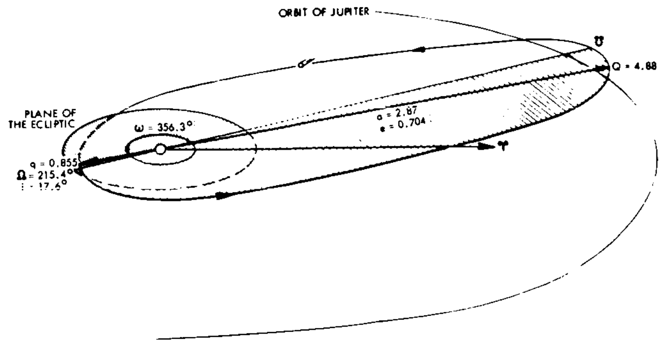

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



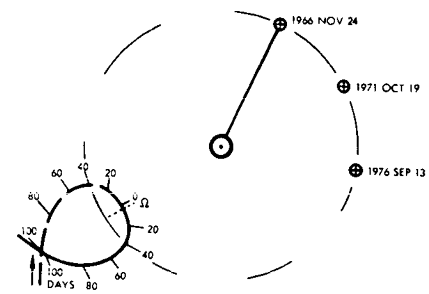

Observed Arcs of Recent Passages

Encke, a Venus type comet, is inclined by 12.4 degrees and is the shortest period comet known. It has been successfully observed on almost every apparition. Therefore, its elements are known the best of all the comets and this comet appears to be most appropriate for a comet mission.

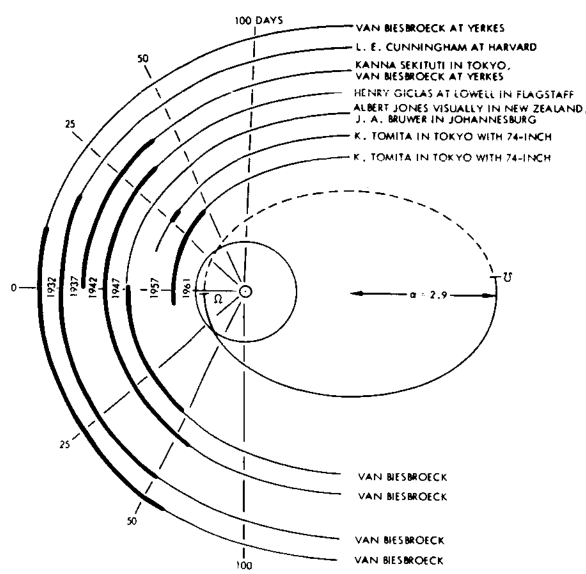
# GRIGG-SKJELLERUP




Orbit of the Comet



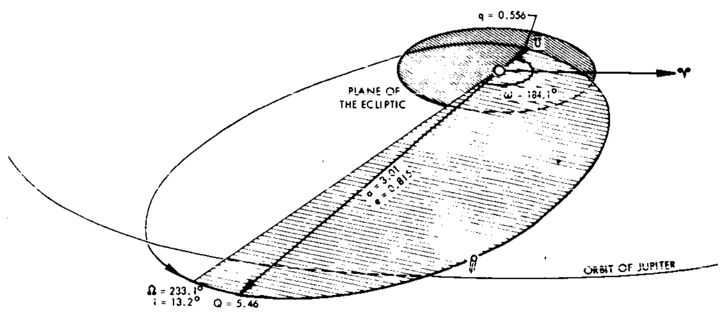

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



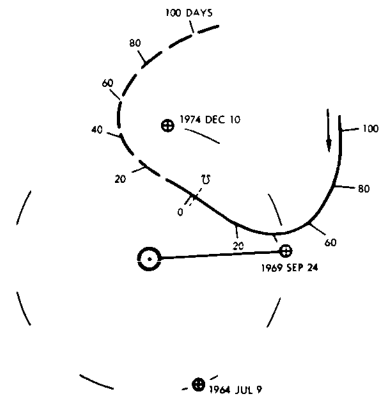

Observed Arcs of Recent Passages

Grigg-Skjellerup, a Venus type comet, has the second shortest period, 4.9 years. It is inclined 17.6 degrees and is relatively eccentric, e = 0.7. Moreover, the earth is not very well located during its next three appearances, 1966, 1971, and 1976, and high injection velocities as well as rather long flight times are required. Three of four apparitions after 1976 will make this a very appealing mission, especially since its orbit will have been very accurately observed.

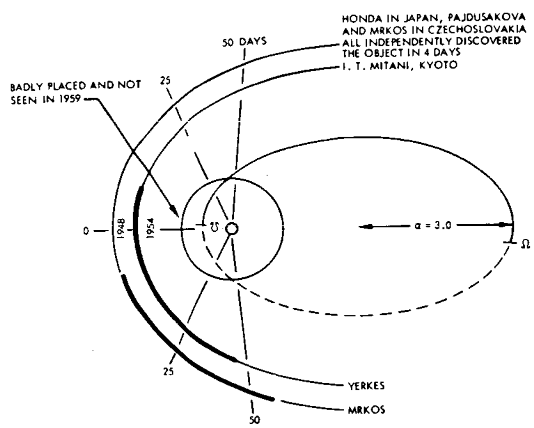
# HONDA-MRKOS-PAJDUSAKOVA




Orbit of the Comet



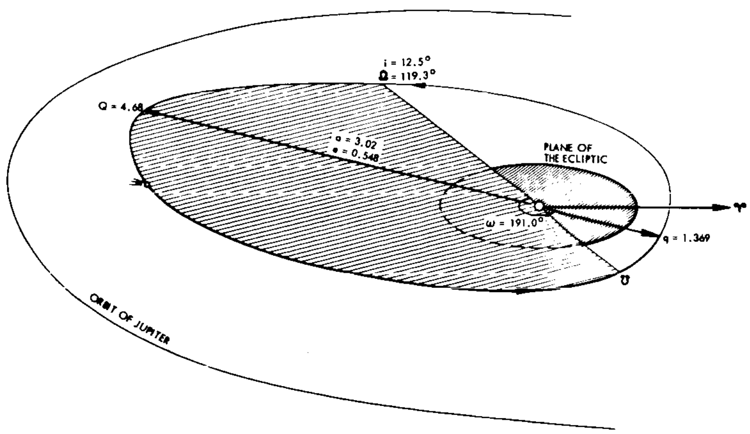

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



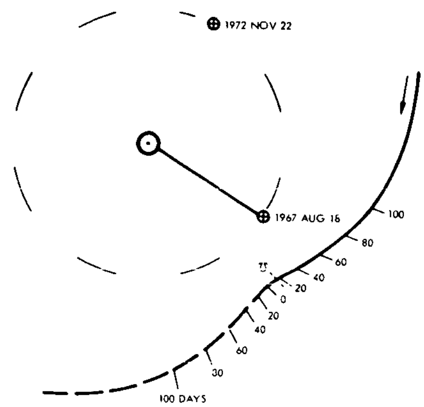

Observed Arcs of Recent Passages

Honda-Mrkos-Pajdusakova, a Venus type comet, was discovered recently, 1948. Although missed in its last apparition in 1959, the earth will be excellently placed for intercept in its 1969 and 1974 apparitions; however, the 1964 apparition will require long flight times at reasonable velocities.

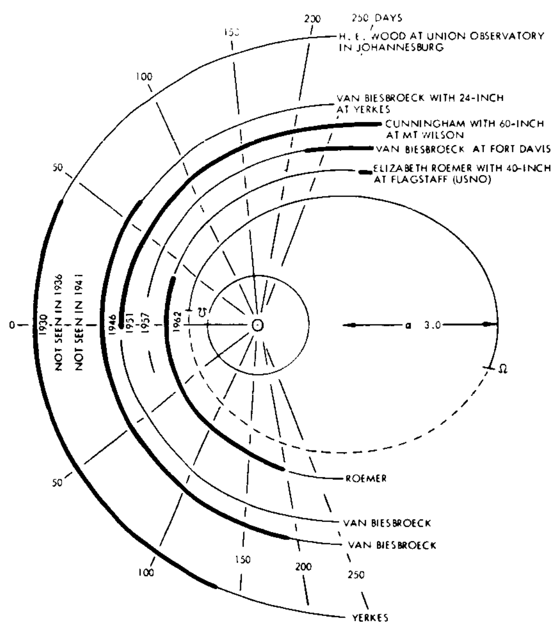
# TEMPEL (2)




Orbit of the Comet

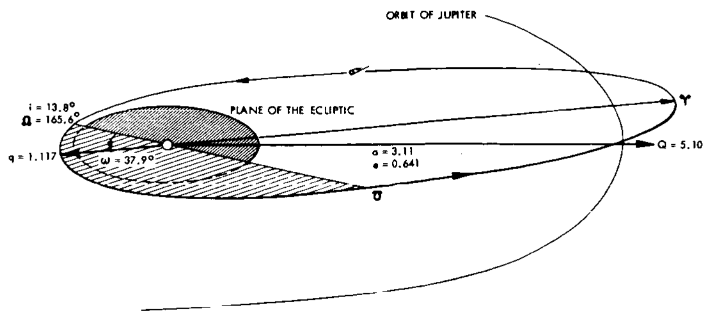



Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)

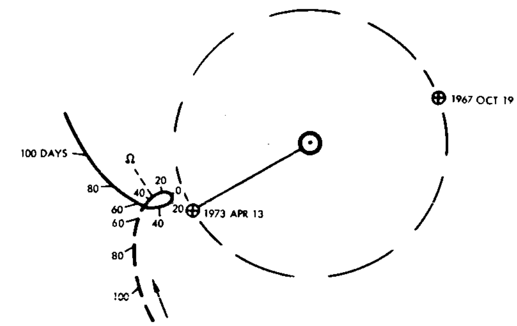



Observed Arcs of Recent Passages

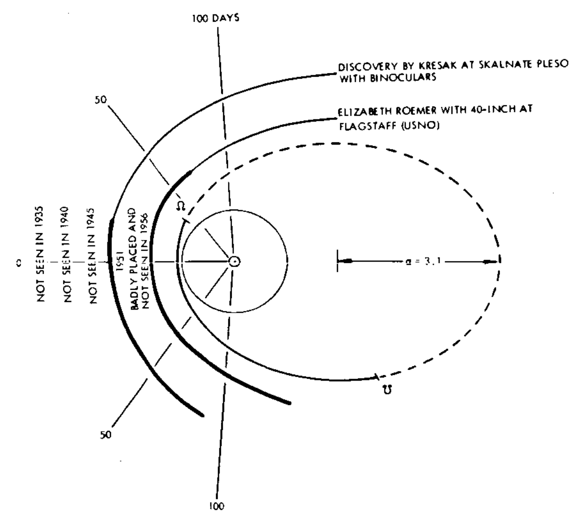
Tempel (2), a Mars type orbit, has been observed frequently although its orbit is still not known very accurately. Its inclination, which is 12.5 degrees, is comparable to that of Encke. In general, as can be seen, it will be very easy to observe its 1967 apparition and should provide an excellent target at that time, both in terms of velocity required and flight time.




Orbit of the Comet



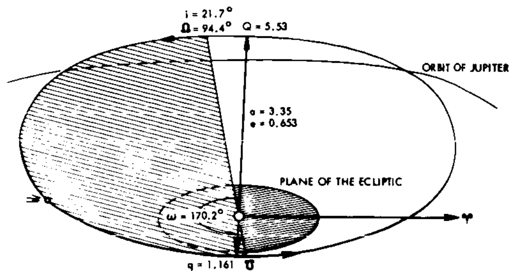

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



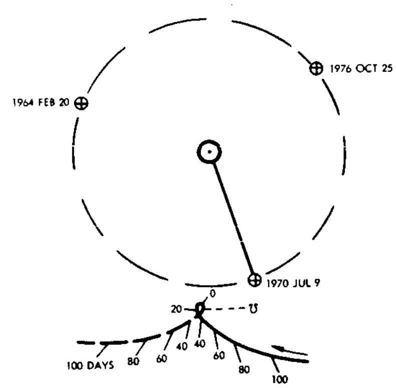

Observed Arcs of Recent Passages

Tuttle-Giacobini-Kresak, a Mars type comet, approaches very close to the earth's orbit. Although it has been frequently missed on its most recent passages, it was observed for a long period of time. The earth is in a very poor position to launch during its 1967 position but it will be in an excellent position in 1973.

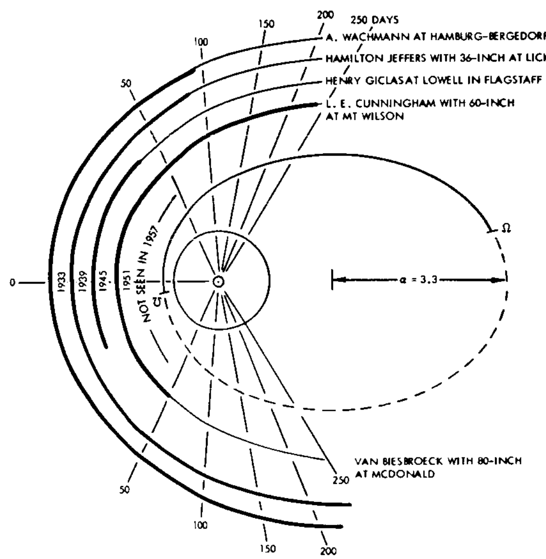
# PONS-WINNECKE




Orbit of the Comet



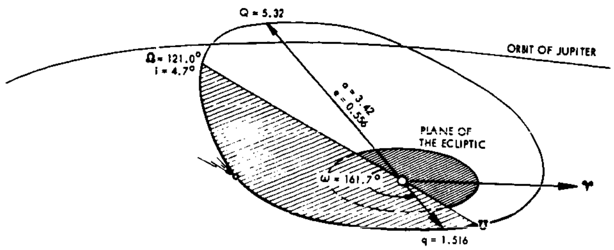

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



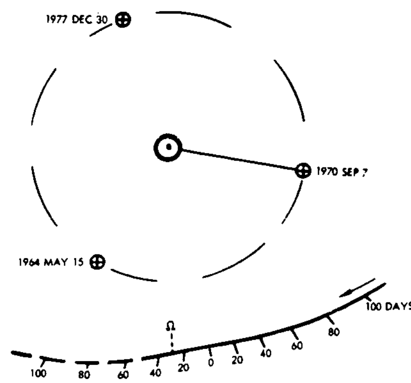

Observed Arcs of Recent Passages

Pons-Winnecke, a Mars type comet, passes very close to the earth's orbit. Although it has been frequently observed, it was missed on its last passage. The position of the earth in its 1964 apparition as well as its 1976 apparition is very poor, but is excellent in its 1970 apparition and at that time should provide an excellent target even though the comet is inclined by 21.7 degrees.

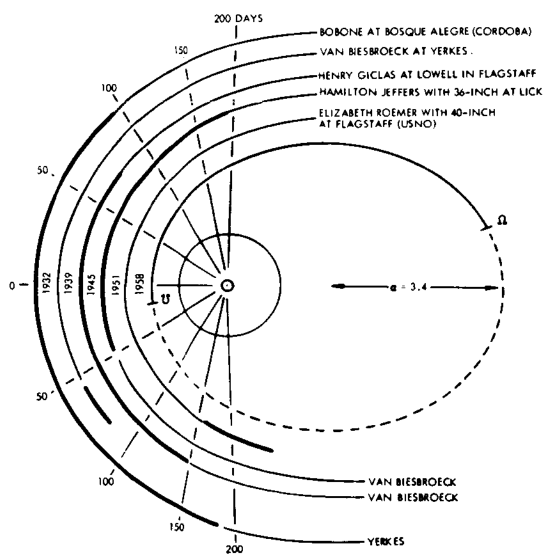
# KOPFF




Orbit of the Comet



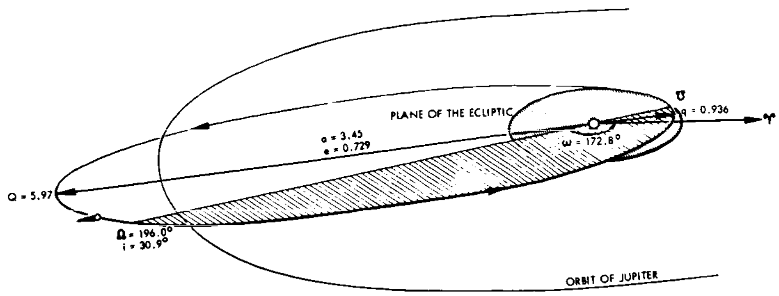

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



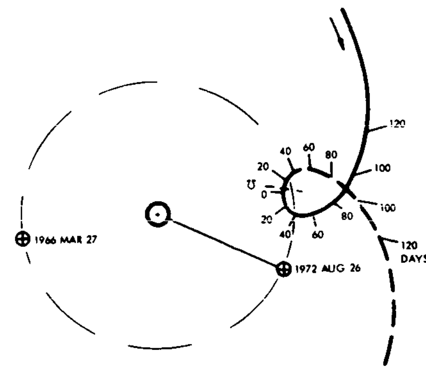

Observed Arcs of Recent Passages

Kopff, a Mars type comet, is a possible target in 1964 although perihelion distance is quite large, 1.5 AU. Moreover, since its descending node is near the orbit of Jupiter, large perturbations can be expected. Its low inclination, 4.7 degrees, simplifies intercept and substantially increases the probability of mission success. The earth is in a good position in 1964 and 1970, but rather poor in 1977.

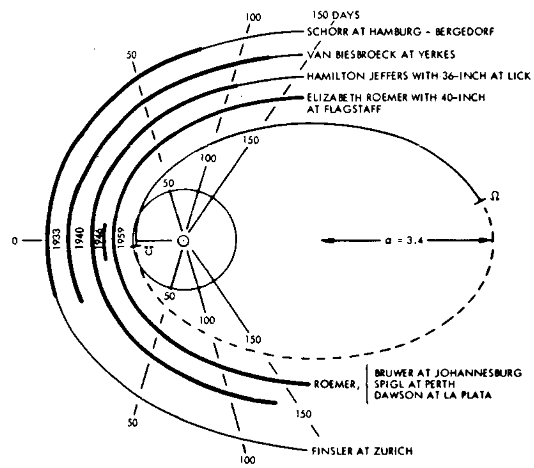
# GIACOBINI-ZINNER




Orbit of the Comet



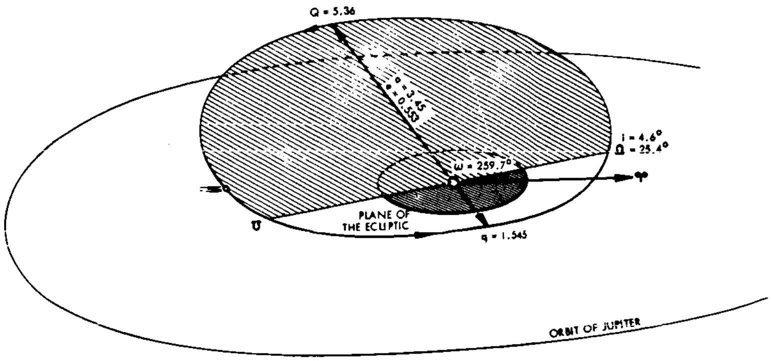

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



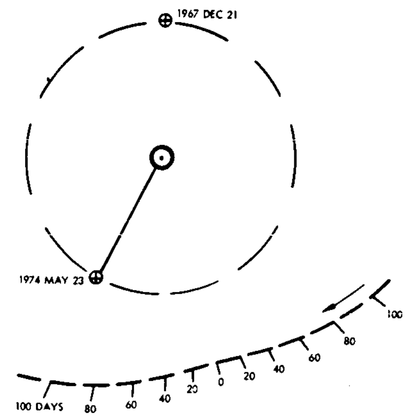

Observed Arcs of Recent Passages

Giacobini-Zinner, a Venus type comet, is quite elliptical and has a very high inclination, 30.9 degrees. Although it appears in both 1966 and 1972 and has frequently been observed, it does not appear to be a very good target, largely because the high inclination will make injection velocity requirements and accuracy requirements severe. The position of the earth is good in 1972, but poor in 1966.

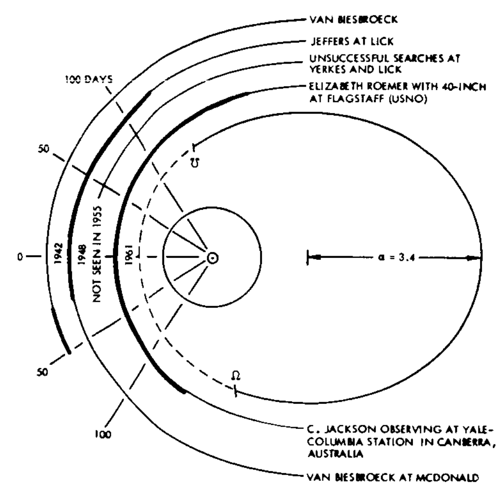
# FORBES




Orbit of the Comet



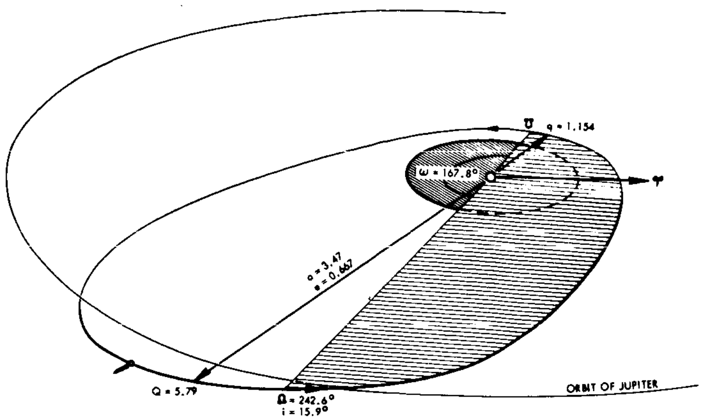

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



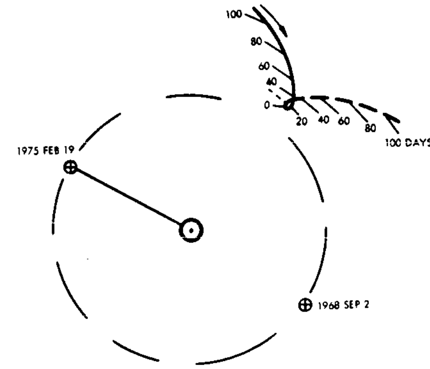

Observed Arcs of Recent Passages

Forbes, a Mars type comet, has a very low inclination. It should not suffer large perturbations from Jupiter since the nodes are almost at right angles to Jupiter's orbit. Although there have been successful observations of this comet, its orbit does not appear to be known well enough to be considered for a mission in the near future. However, the position of the earth is very good in 1974, but it is poor in 1967.

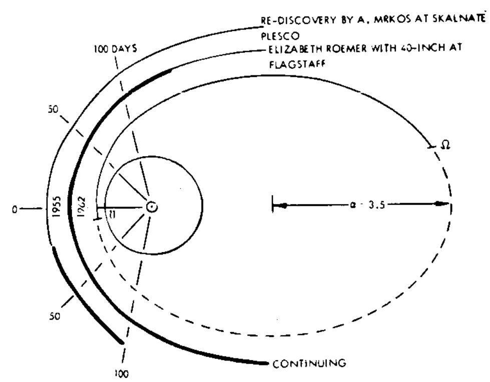
# PERRINE-MRKOS




Orbit of the Comet



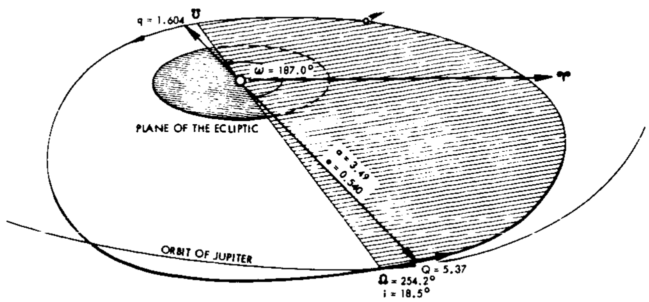

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



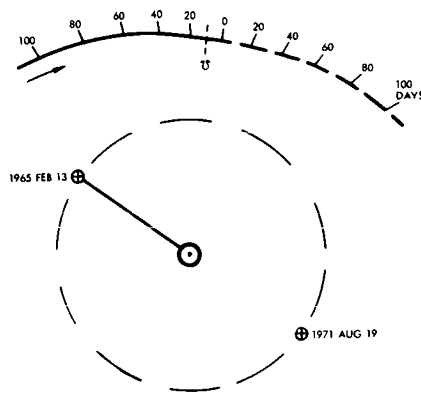

Observed Arcs of Recent Passages

Perrine-Mrkos, a Mars type comet, approaches quite close to the earth's orbit and should present a possible target in 1968. It is subject to large perturbations from Jupiter since it crosses Jupiter's orbit almost at the nodal point. Its inclination of 15.9 degrees does not make it a less feasible target. Observations of this comet during its next apparitions should be excellent. The position of the earth is poor in 1975 and flight times at reasonable velocities will be long.

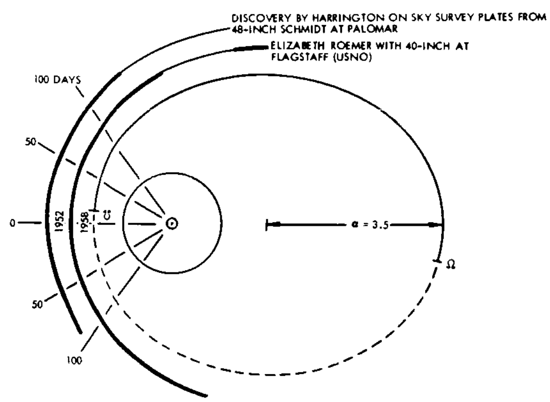
WOLF-HARRINGTON




Orbit of the Comet



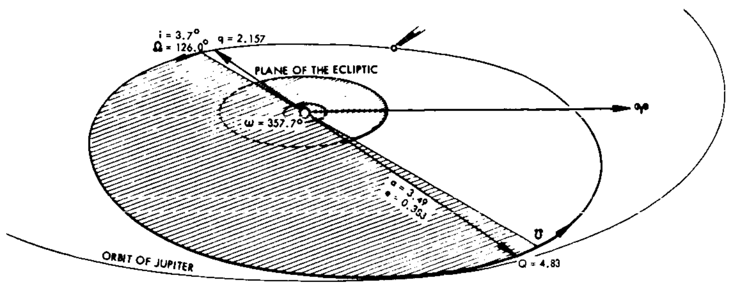

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



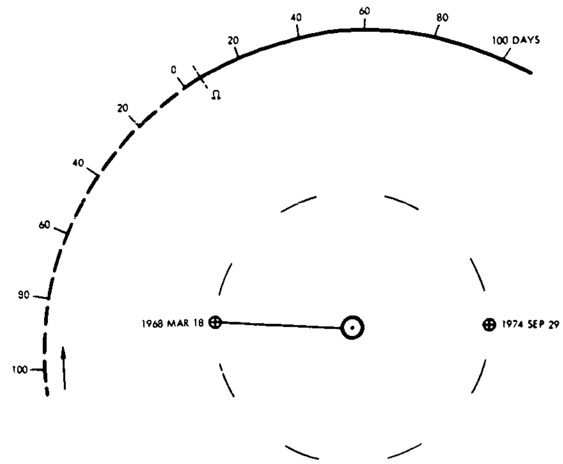

Observed Arcs of Recent Passages

Wolf-Harrington, a Mars type comet, does not come very close to the earth at perihelion passage and has a fairly high inclination of 18.5 degrees. Although observation of the comet in 1965 should be excellent, its elements are not know well enough to warrant a mission at that time and at its next appearance in 1971, observation should not be as good. Probability of a successful mission to this comet is low, especially in 1971 when the position of the earth is not good and flight times will be long.

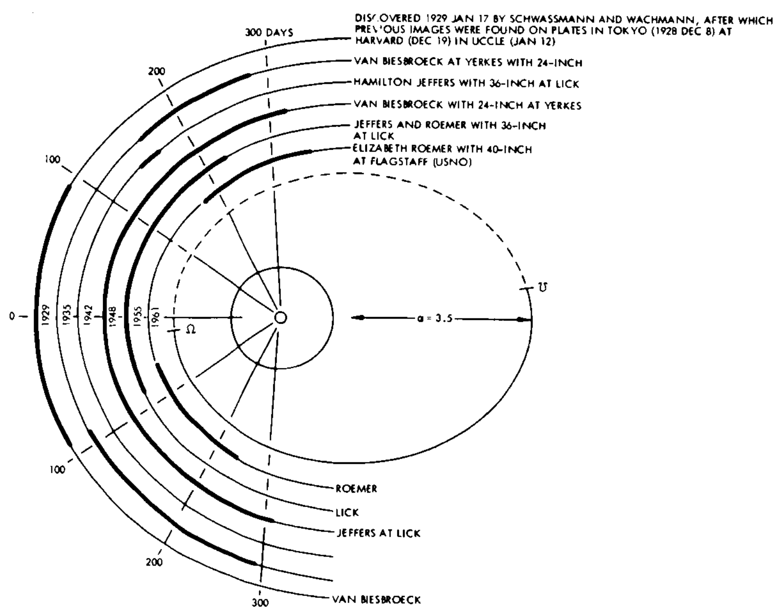
# SCHWASSMANN-WACHMANN (2)




Orbit of the Comet

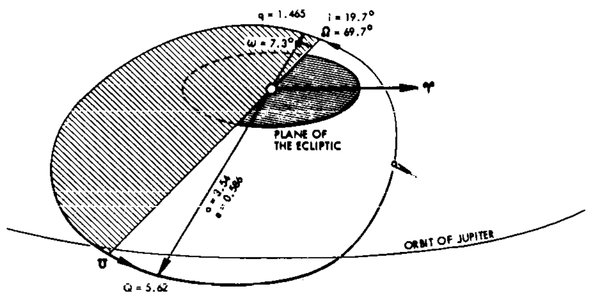



Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)

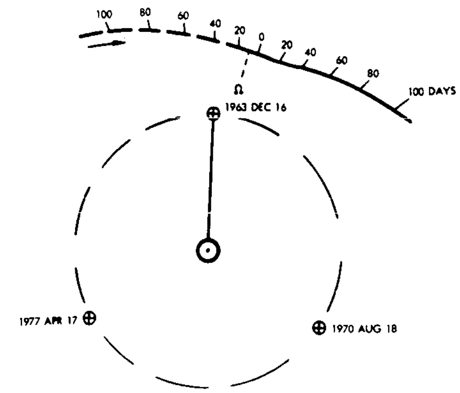



Observed Arcs of Recent Passages

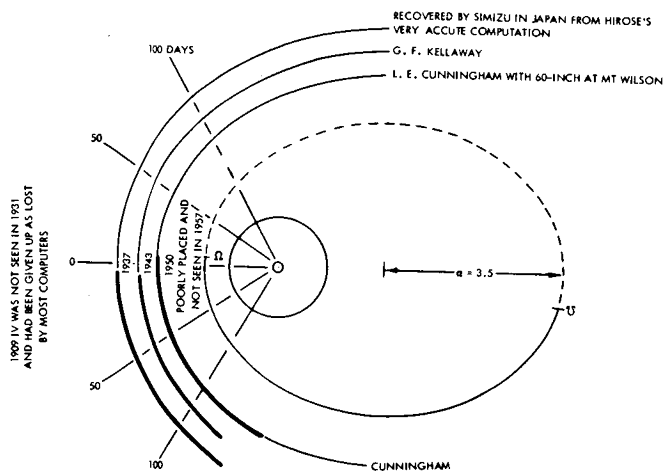
Schwassmann-Wachmann (2), a Mars type comet, has been observed frequently. However, it has a large perihelion distance, over 2 AU, and hence, it is not a desirable target since its great distance from the sun at the intercept point will considerably complicate power supply and communications problems. The position of the earth is good in 1968, but flight times at reasonable velocities will be long in 1974.




Orbit of the Comet



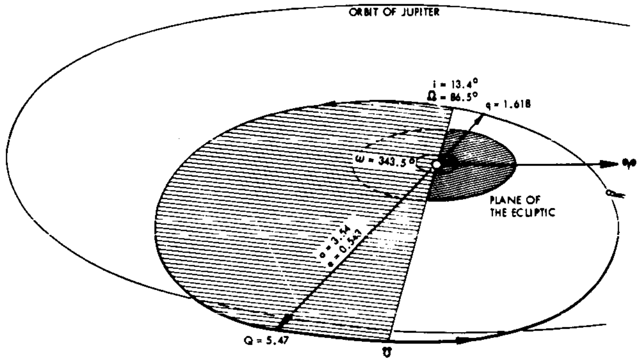

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



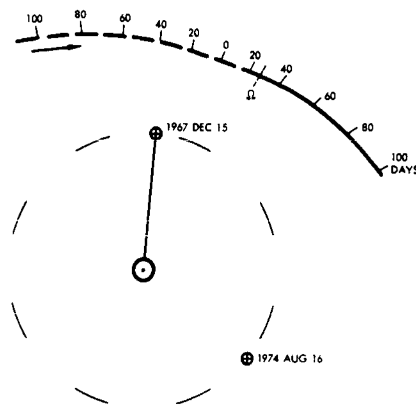

Observed Arcs of Recent Passages

Daniel, a Mars type comet, will be in an excellent position for observation in its December 1963 passage and its orbit could be computed accurately. However, its inclination of 19.7 degrees, as well as the position of the earth at the 1970 and 1977 appearances, makes it a poor target at those times.

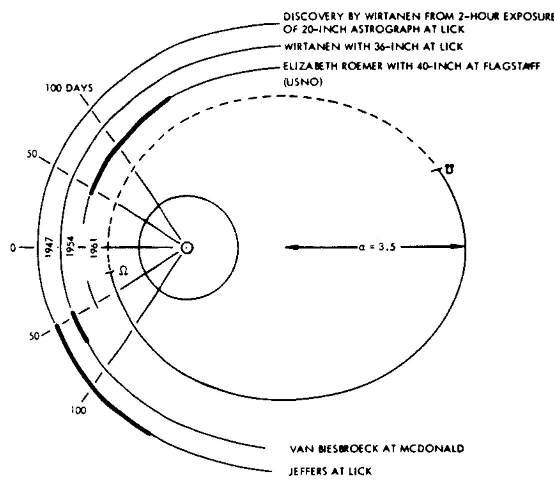
# WIRTANEN




Orbit of the Comet



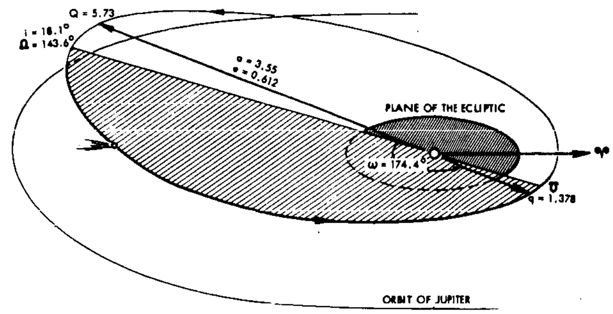

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



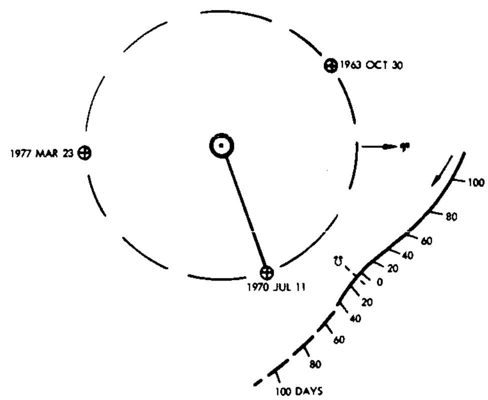

Observed Arcs of Recent Passages

Wirtanen, a Mars type comet, is a possible target in 1967; however, its orbit at the present time is not known to a high accuracy. Moreover, its distance at perihelion is a substantial 1.6 AU which will complicate solar power supply problems. However, during its next apparition in 1967, observation conditions should be excellent with good tracking prior to launch and could provide an excellent target. The position of the earth at the 1974 apparition will be poor.

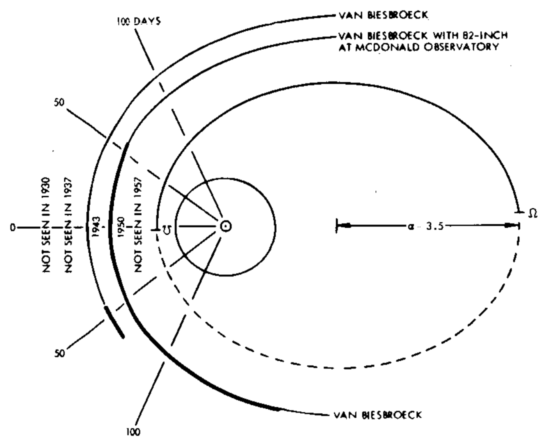
# D'ARREST




Orbit of the Comet



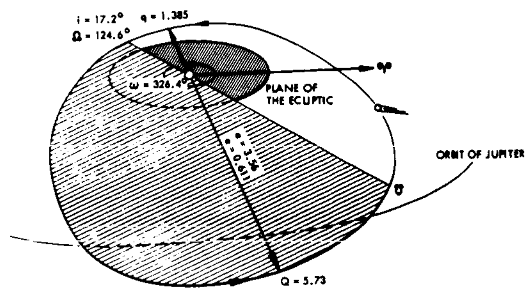

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



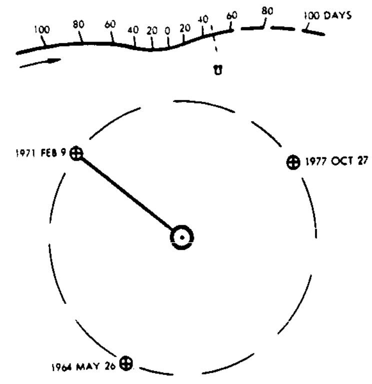

Observed Arcs of Recent Passages

D'Arrest, a Mars type comet, could be a good target in 1970 since observations during 1963 could be used to determine its orbit to high accuracy. However, since it is inclined by 18.1 degrees, the guidance and propulsion requirements will be magnified. The position of the earth is poor in both the 1970 and 1977 apparitions and flight times will be long for reasonable velocities.

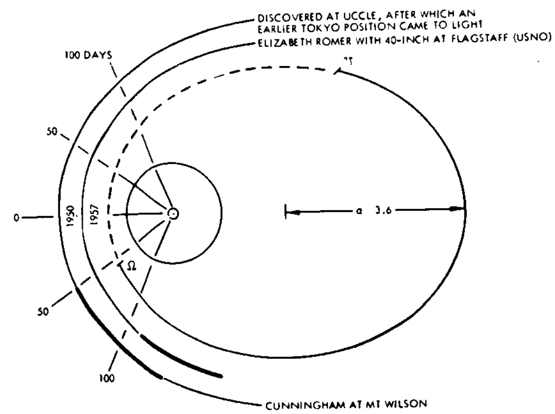
# AREND-RIGAUX




Orbit of the Comet



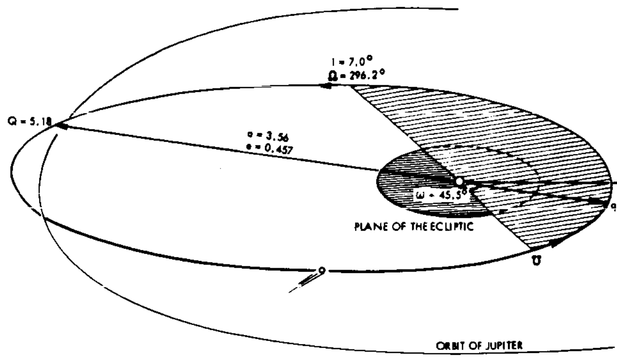

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



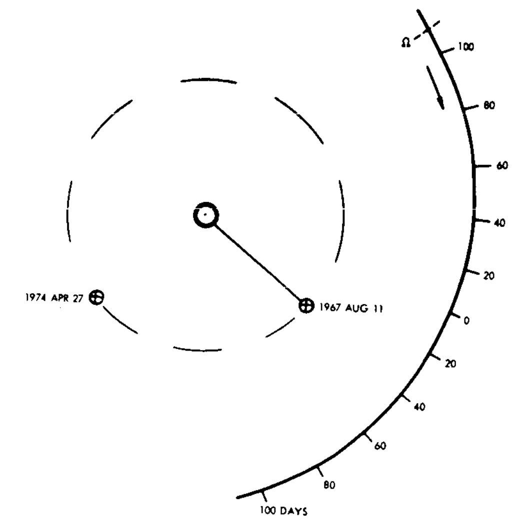

Observed Arcs of Recent Passages

Arend-Rigaux, a Mars type comet, has not been frequently observed and hence, would be a very marginal mission. Moreover, the comet is inclined by 17.2 degrees which complicates the guidance problem. However, the position of the earth in its 1971 apparition is excellent, both in terms of injection velocity and flight time.

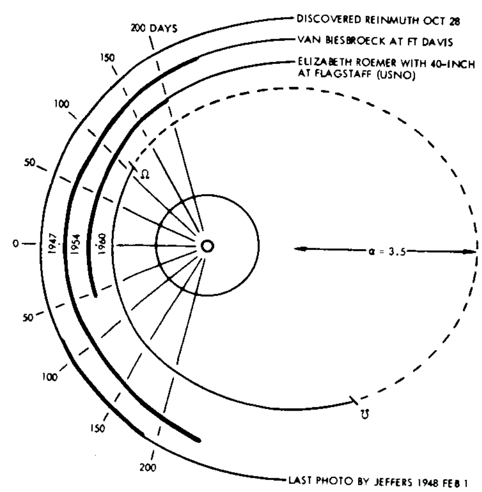
# REINMUTH (2)




Orbit of the Comet



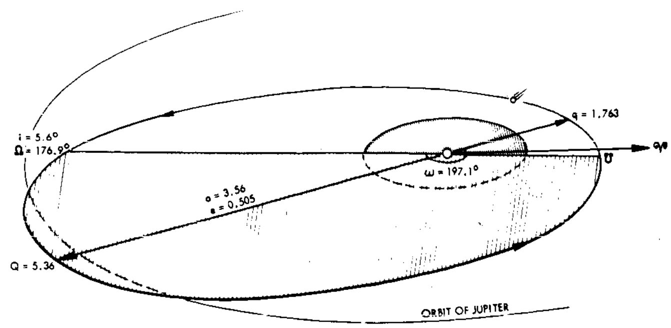

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



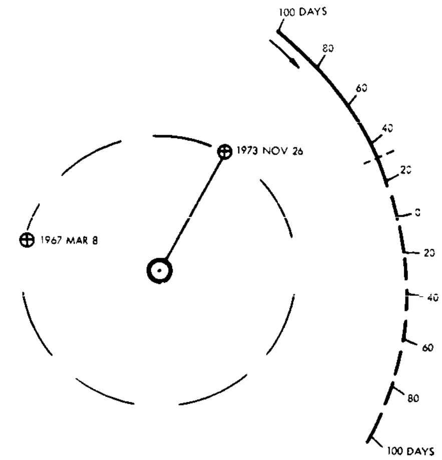

Observed Arcs of Recent Passages

Reinmuth (2), a Mars type comet, is not steeply inclined; however, it is far from the sun at perihelion which complicates temperature control and solar power supply problems. Observation of the comet during 1967 will be quite good but during 1974 will be difficult. Reasonable velocity trajectories will have extremely long flight times, especially in 1974. For these reasons, this comet was not analyzed in Section IV.

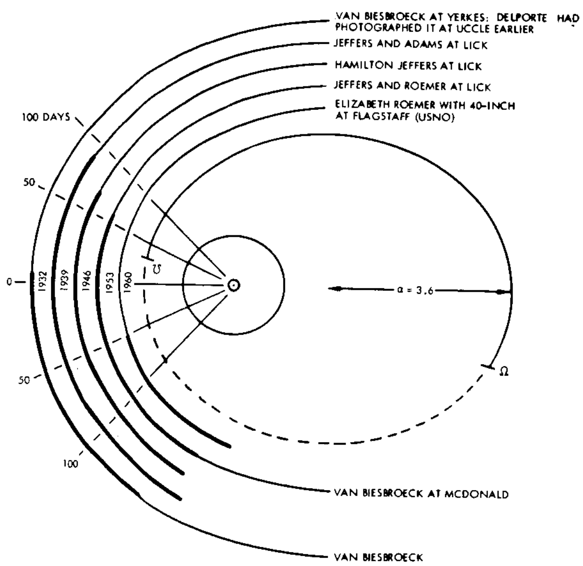
# BROOKS (2)




Orbit of the Comet



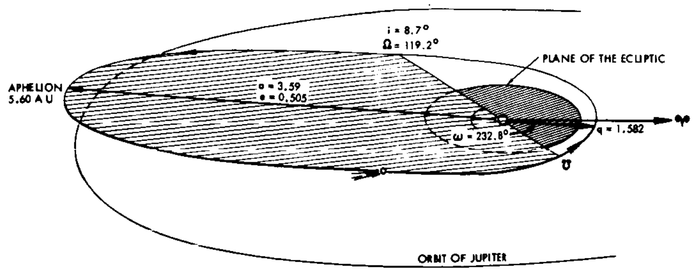

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



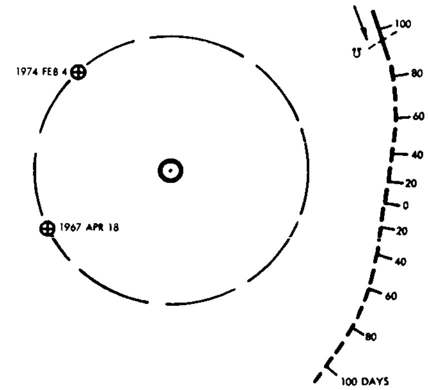

Observed Arcs of Recent Passages

Brooks (2), a Mars type comet, has been regularly observed. However, its perihelion distance is 1.76 AU which will somewhat complicate the solar power supply problem. Moreover, the earth is in a relatively poor position in terms of velocity and lifetime requirements during 1967; thus, a sensible, reasonable mission could not be considered until 1973.

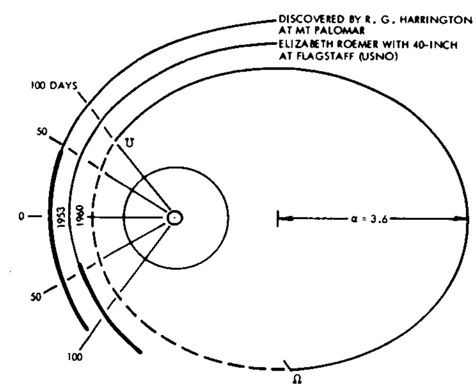
# HARRINGTON (2)




Orbit of the Comet



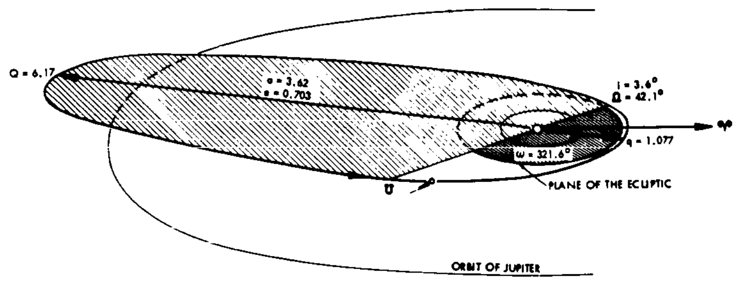

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



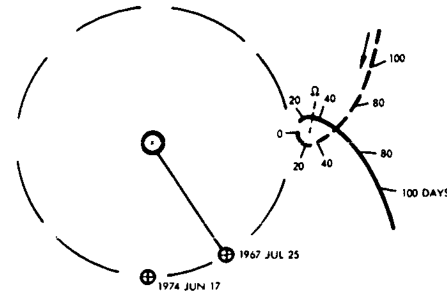

Observed Arcs of Recent Passages

Harrington (2), a Mars type comet, has not been observed frequently. Moreover, during both of the possible launch periods in 1967 and 1974 the position of the earth is extremely poor for launching to this comet at reasonable injection velocities and flight times. For these reasons, this comet is not analyzed in Section IV.

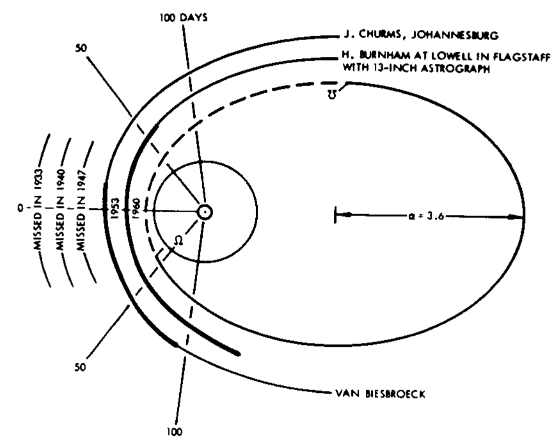
# FINLAY




Orbit of the Comet



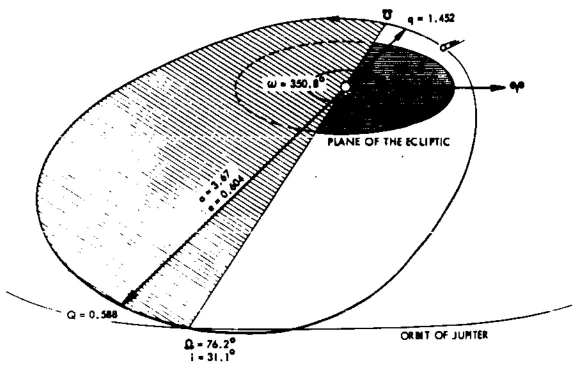

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



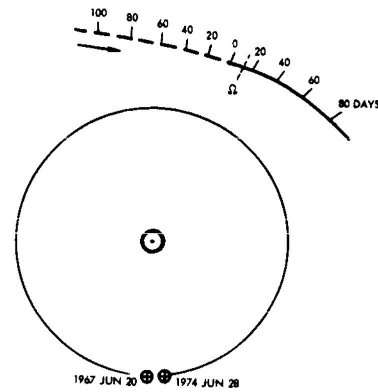

Observed Arcs of Recent Passages

Finlay, a Mars type comet, makes a very close approach to the earth's orbit and has a relatively low inclination. Although observed a number of times it has frequently been missed and hence its orbit is not well known. The earth is favorably located for launching to this comet during the next two apparitions in 1967 and 1974.

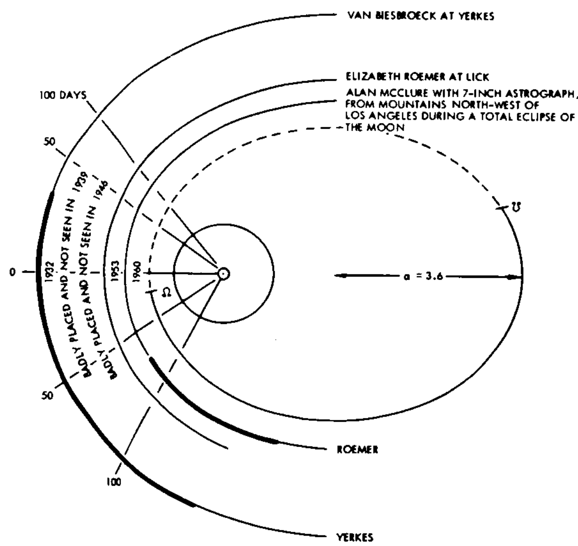
# BORRELLY




Orbit of the Comet



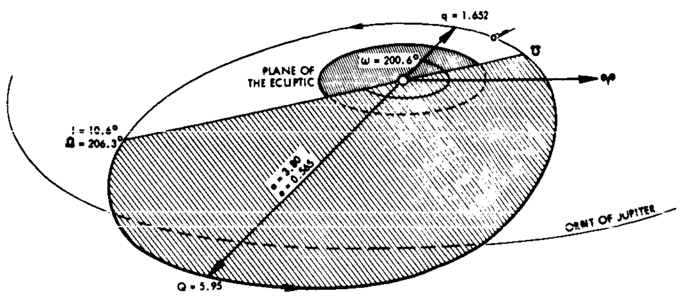

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



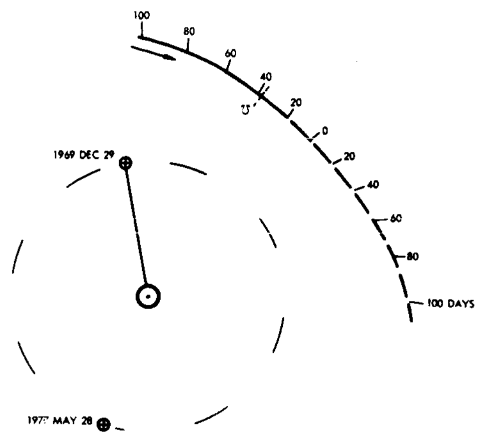

Observed Arcs of Recent Passages

Borrelly, a Mars type comet, has frequently been missed during its approach near earth. It will occasionally be subject to large perturbations by the planet Jupiter since the ascending node is essentially on Jupiter's orbit. During its next two appearances in 1967 and 1974, the earth is very poorly located in terms of reasonable flight times and injection velocities. For these reasons this comet was not analyzed in Section IV.

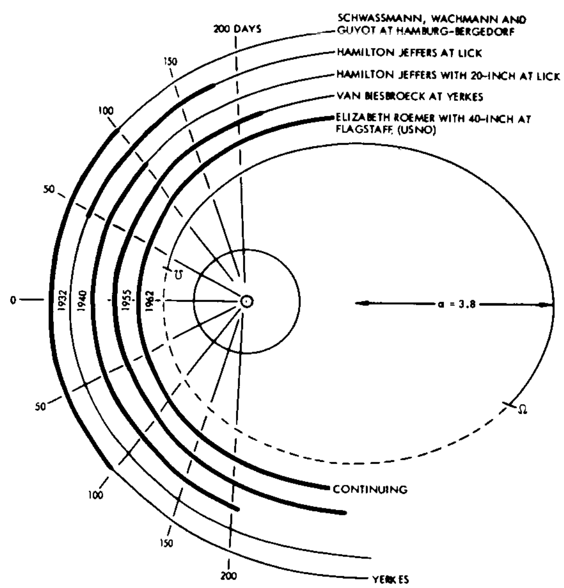
# FAYE




Orbit of the Comet



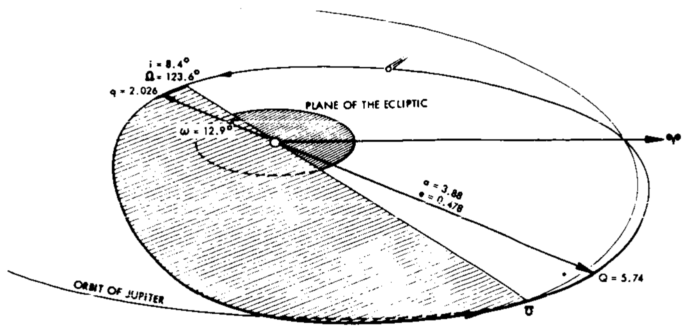

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



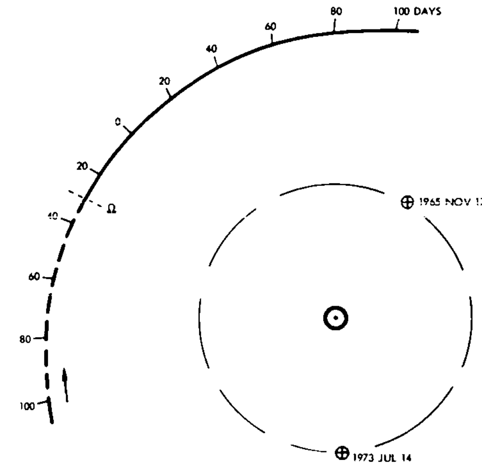

Observed Arcs of Recent Passages

Faye, a Mars type comet, has been very frequently observed and has a reasonable inclination. The position of the earth at its next apparition in 1969 is very satisfactory in terms of injection velocity and reasonable flight times. It has a reasonable inclination of 10.6 degrees.

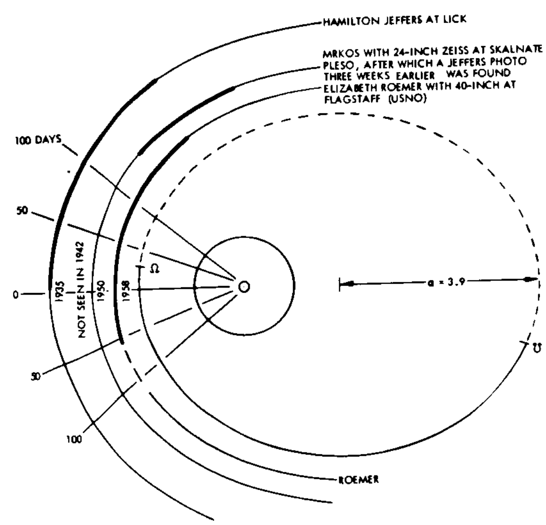
## REINMUTH (1)




Orbit of the Comet



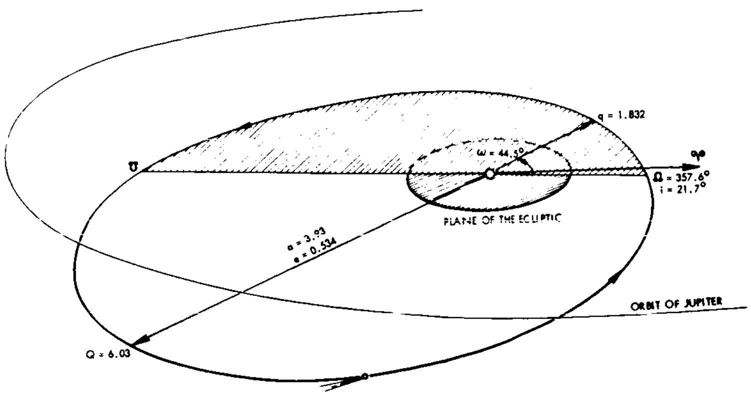

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



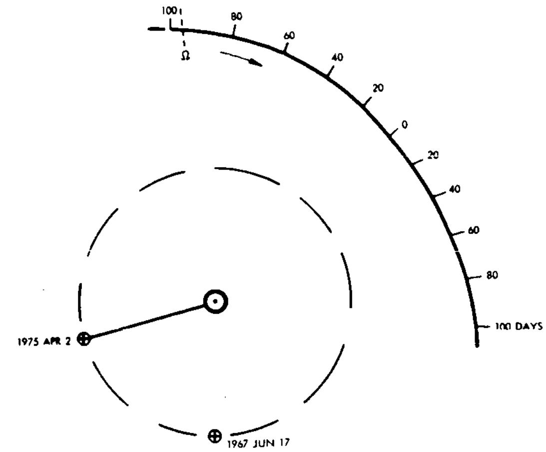

Observed Arcs of Recent Passages

Reinmuth (1), a Mars type comet, has a perihelion distance of 2 AU which will complicate power supply problems and implies long flight times at reasonable velocities. Also, since its descending node is almost at Jupiter's orbit, it will occasionally be subject to large perturbations. In addition, the position of the earth on its 1965 apparition is very poor in terms of reasonable injection velocities and flight times. In 1973 its position is somewhat better; nevertheless, all flight times at reasonable velocities should exceed 6 months. For these reasons this comet is not analyzed in Section IV.

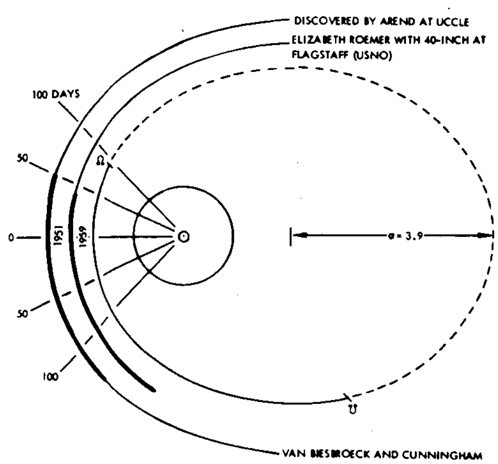
# AREND




Orbit of the Comet



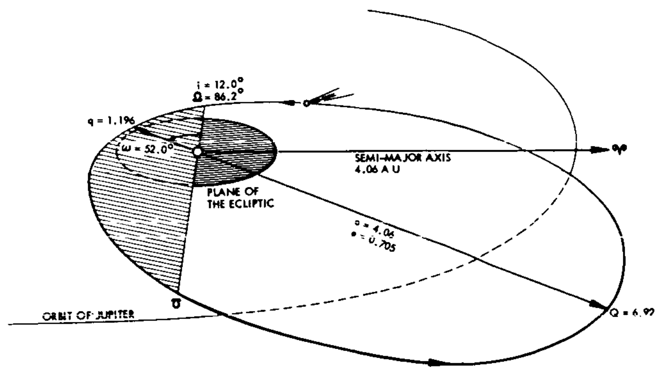

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



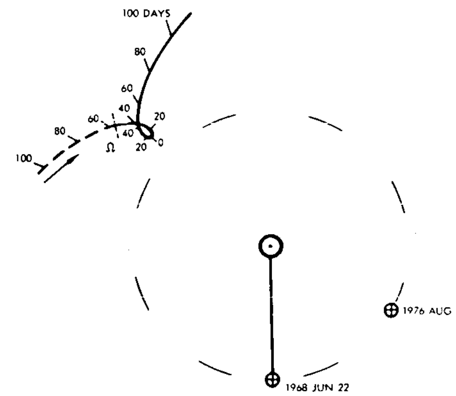

Observed Arcs of Recent Passages

Arend, a Mars type comet, has a perihelion distance of 1.8 AU and an inclination of 21.7 degrees. Although both of these factors complicate guidance as well as the power supply problems, the long trip time missions of the order of 250 days can be carried out in either 1967 or 1975.

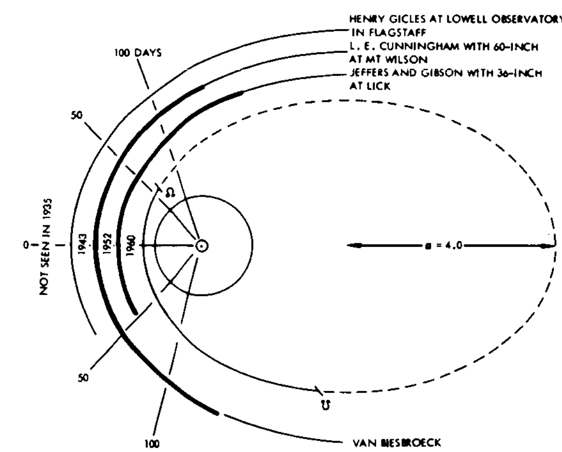
# SCHAUMASSE




Orbit of the Comet



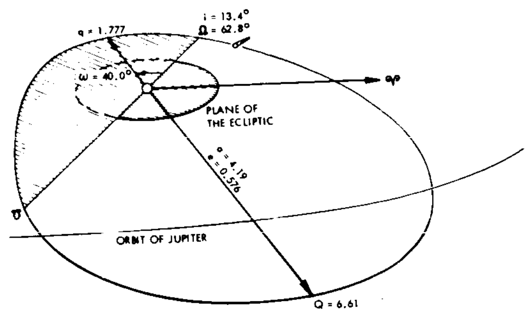

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



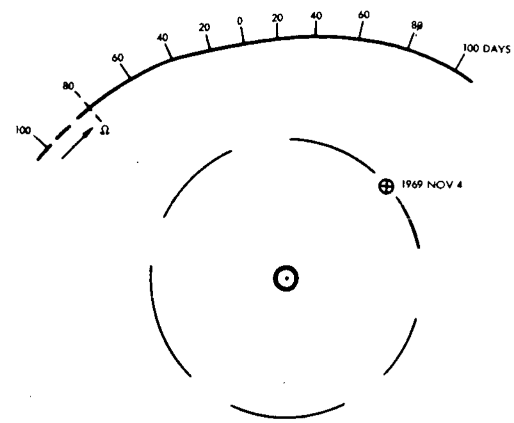

Observed Arcs of Recent Passages

Schaumasse has been observed a number of times and comes quite close to the earth's orbit. However, since its nodes are far from perihelion, it will be far out of the plane of the ecliptic at that time and this will complicate the intercept trajectory. Moreover, in both its 1968 and 1976 apparitions the position of the earth is not suitable for intercept in terms of injection propulsion requirements and communications at intercept.

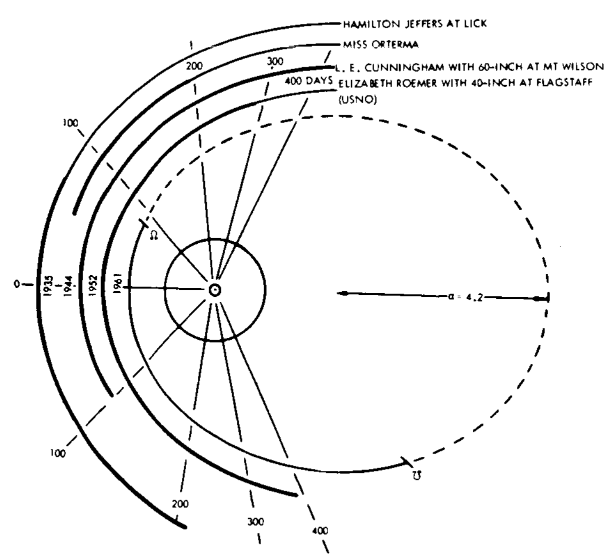
# COMAS-SOLA




Orbit of the Comet



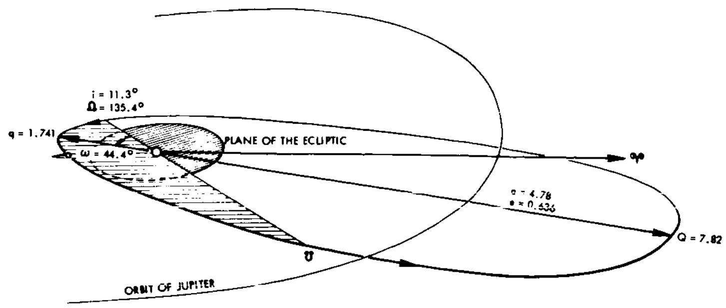

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



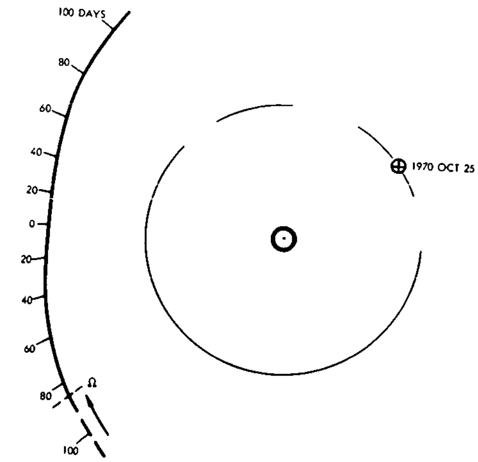

Observed Arcs of Recent Passages

Comas-Sola, a Mars type comet, has been observed frequently for long durations and is a possible target during 1969. However, since its descending node is near the orbit of Jupiter, substantial perturbations must be anticipated. Moreover, since its perihelion distance is quite large, 1.8 AU, thermal control and solar power supply problems are increased. For this reason, this comet is not analyzed in Section IV.

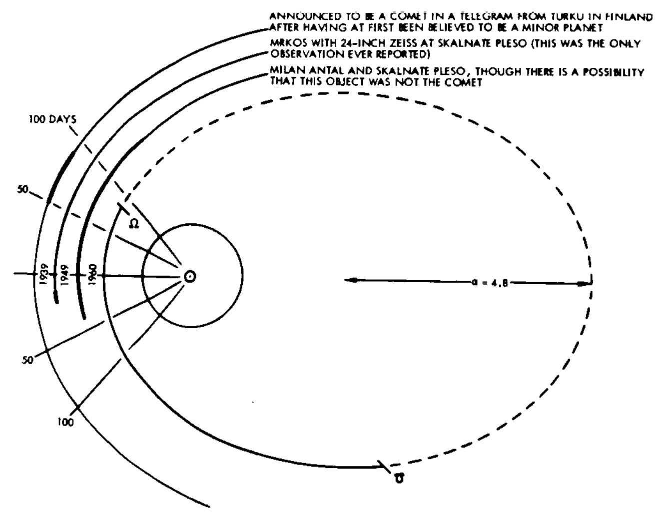
# VÄISÄLÄ (1)




Orbit of the Comet



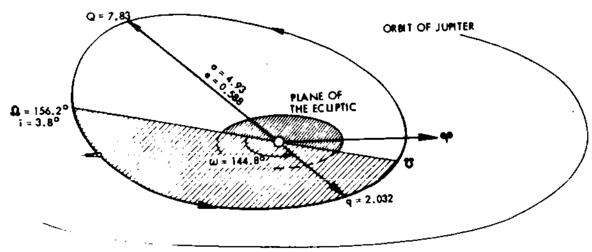

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



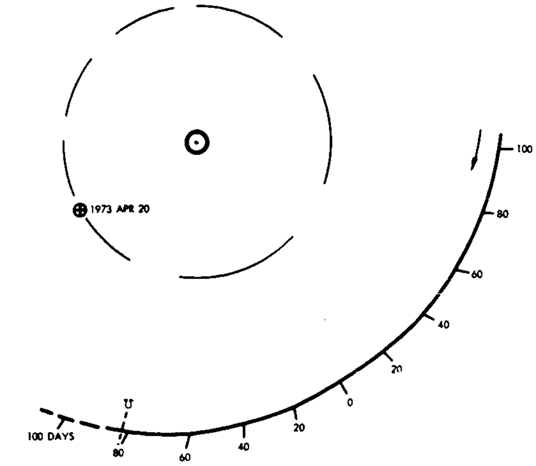

Observed Arcs of Recent Passages

Väisälä (1), a Mars type comet, has a long period, 11 years. Although it has been observed in all of its recent passages, its orbit has not been well determined and the opportunities for intercept are very poor in its next apparition in 1970. Therefore, this comet has not been analyzed in Section IV.

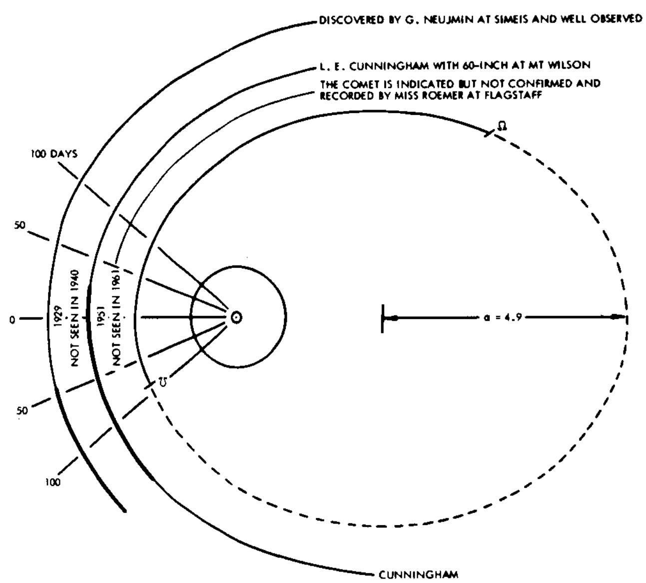
# NEUJMIN (3)




Orbit of the Comet



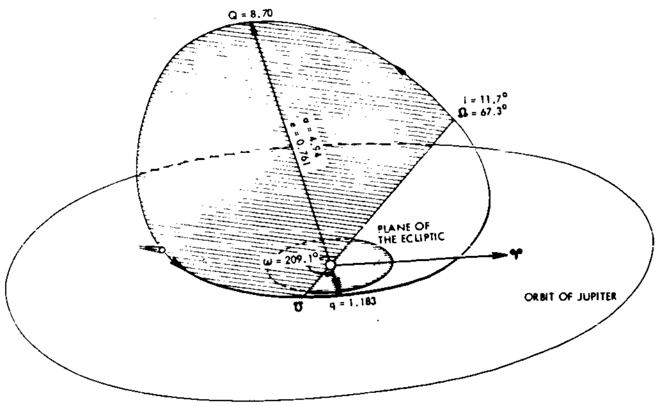

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



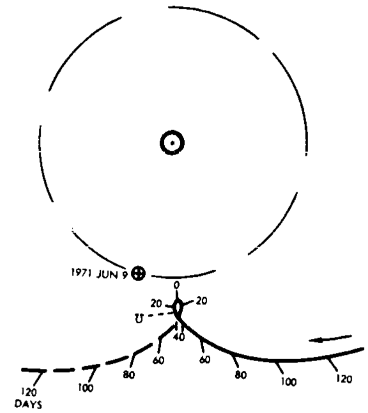

Observed Arcs of Recent Passages

Neujmin (3), a Mars type comet, has not been observed frequently. Moreover, its perihelion distance is 2 AU. Therefore, although the earth is in a reasonable position during its next apparition in 1973, it was not analyzed in Section IV.

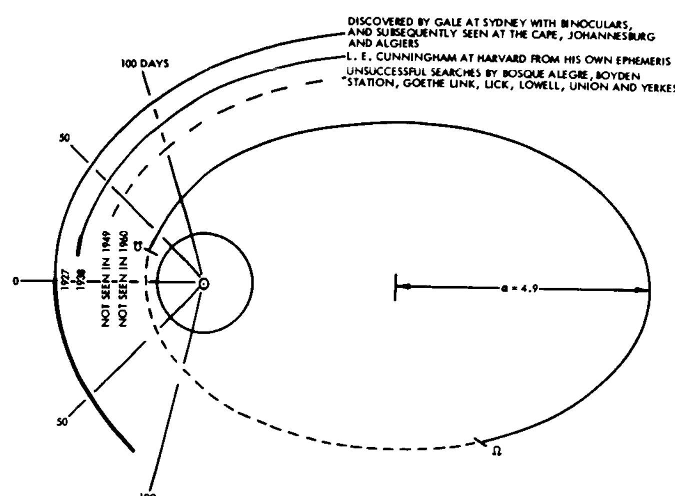
# GALE




Orbit of the Comet



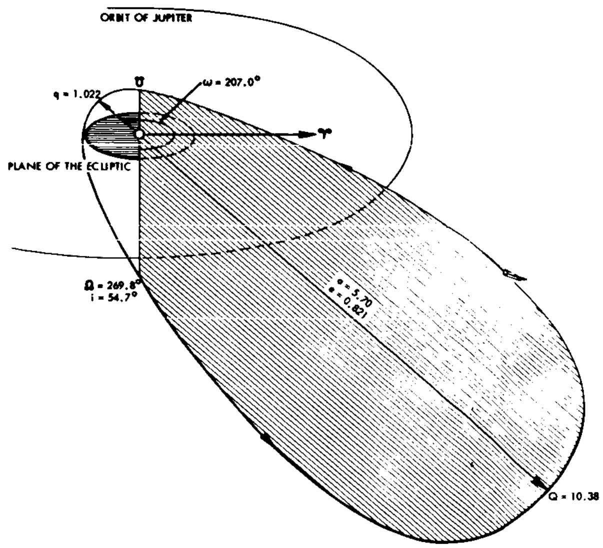

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



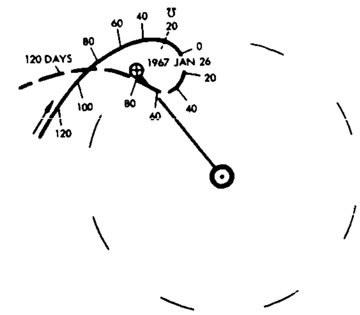

Observed Arcs of Recent Passages

Gale, a Mars type comet, approaches quite close to the earth's orbit. Although it is in a very appropriate position during its next passage in 1971, it was not analyzed in Section IV.

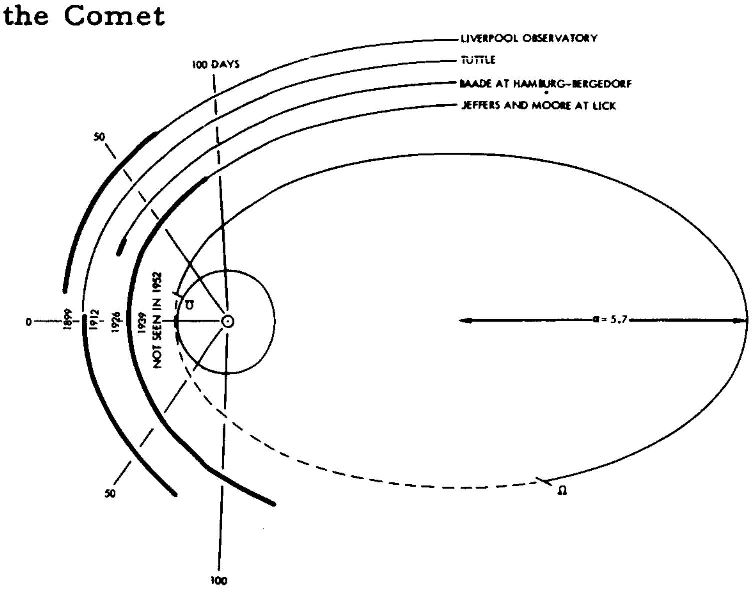
# TUTTLE




Orbit of the Comet



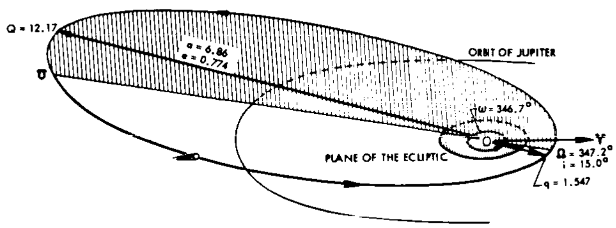

Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)



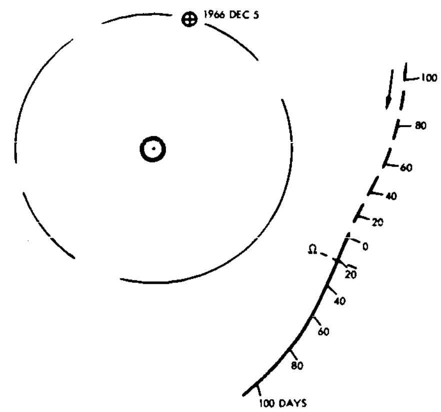

Observed Arcs of Recent Passages

Tuttle, a Venus type comet, is very eccentric and has a period of more than 13 years. It was not observed in its last apparition in 1952. It is also inclined by 54.7 degrees and hence, will present a difficult guidance problem. However, the position of the earth on its next apparition in 1967 will be very good both in terms of observation and in terms of reasonable injection velocities and flight times.

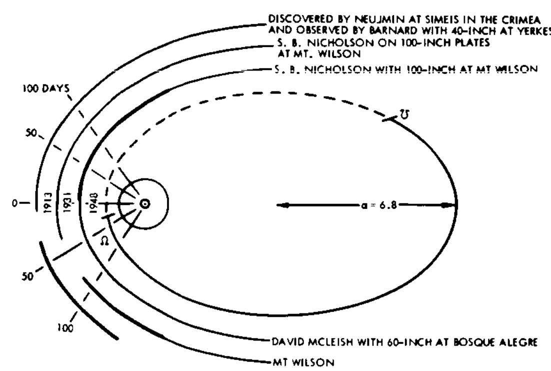
# NEUJMIN (1)




Orbit of the Comet




Orbit of the Comet From a Fixed Earth (Bi-polar Coordinates)




Observed Arcs of Recent Passages

Neujmin (1), a Mars type comet, has a perihelion distance of 1.5 AU and an inclination of 15 degrees. It has also been successfully observed on its recent passages. However, the earth is extremely unfavorably located in its apparition in 1966 and therefore, this comet was not analyzed in Section IV.

## III. PHYSICS OF COMETS AND COMET INTERCEPT EXPERIMENTS

A comet has been defined as a composite body, surrounded by a gaseous atmosphere, and moving around the sun in an elliptical orbit, crossing the plane of the ecliptic at any angle. Of particular interest in the study of comets have been general astronomical observations (occurrence and orbits), the structure and composition, the physical and chemical properties and their behavior in the particular environment of the comet, and the inferences from these observations as to the creation, life,and general cosmological significance of comets. This section first summarizes some of the available knowledge of comets and their behavior and also points out areas where significant questions still exist, and will then attempt to evaluate the information to be derived from a comet intercept flight. It should be pointed out at the onset that comets are individual apparitions, and that many of the statements applied to the general group are thus only qualitative in nature. It should also be pointed out that studies of comets are difficult and that, until recently, visual observation rather than photometric determinations of brightness and spectral emission have provided the bulk of data with respect to comets.

### A. GENERAL PHYSICAL PROCESSES IN COMETS

Comets, in general, are postulated to consist of a rather small nucleus, composed of solid material, a gaseous envelope called the coma, and a less dense gaseous region called the tail. The nucleus is believed to be only several kilometers in diameter, the coma perhaps $10^4$ - $10^5$ kilometers in diameter and the tail region about $10^6$ kilometers long and $10^4$ kilometers wide.

The presently accepted model of the nucleus is the "icy conglomerate" model proposed by Whipple in which the nucleus consists of a mass of frozen gases containing interspersed solid micrometeorite particles. This model offers significant advantages over the previously accepted "sand bank" model in which the nucleus was postulated to consist of small solid particles; the gas supply was occluded and absorbed gases. The "icy conglomerate" model suggests a much larger gas reservoir and in addition can explain the survival of comets at small heliocentric distances where the solar thermal energy input and the tidal force is large. An upper limit to the cometary mass is set by the fact that comets do not appear to exert any observable gravitational effects on close passage to planets or their satellites; lower limits to the cometary mass are set by cometary survival at small heliocentric distances although the disruptive effects depend largely upon the assumed physical structure. In general, the cometary mass is assumed to be $10^{17}$ - $10^{20}$ gms.

Evidence for the presence of solid material is derived from two sources. Firstly, meteor streams are known to be associated with comets. Secondly, some of the light observed from the coma and certain tails has the spectrum and polarization characteristic of reflected sunlight. Emission spectra of some meteors on entry into the earth's atmosphere are characteristic of iron.

Thus, the present idea is that the frozen gaseous surface is sublimed by the solar thermal radiation as the comet approaches the sun. Interspersed with the gases are micrometeorite fragments. In the newer comets, where "new" is meant to imply that the comet has not completed many solar orbits, the rate of solid particle emission is enhanced with respect to the gases. This presumably implies that in the older comets the solid material occurs in larger fragments; it is not clear how this agglomeration occurs in the presumably frozen nucleus.

As the comet approaches the sun, the sublimation of material from the surface of the nucleus increases. The brightness of the comet increases rapidly, which is accounted for by the increase of solar radiation intensity and the increase in density of the radiating gases and reflecting particles. The emission from the coma consists of the molecular spectra of a wide variety of neutral free radicals including CN, $C_2$, $C_3$, NH, $NH_2$, Na, and the ionized stable molecules $CO^+$, $N_2^+$ and $CO_2^+$. The dimensions of the coma appear to be different depending upon the spectral region observed which indicates a variable distribution of molecular species. The densities in the coma are believed to range from $10^{10}$/cc near the nucleus to perhaps $10^3$ at the periphery. Although the surface temperature of the icy nucleus is probably $10^o$ - $100^oK$, it is reasonable that the sublimed molecules have a temperature of $100^o$ - $500^oK$. If the density is sufficiently low so that collisions do not occur, then the expansion velocity is about 1 kilometer/sec. The density, estimated from the emission intensity, and the expansion velocity give the rate of gas loss from the nucleus; the "icy conglomerate" model was proposed to account for these loss rates.

It is probable that the gaseous molecular emission is the result of photo-excitation by solar radiation rather than collisional processes because of the low densities. Although only the spectra of free radicals are observed, it has been assumed that the parent molecules are the simplest stable molecules which can be dissociated to yield the observed free radicals. In the "icy conglomerate" model, it is therefore assumed that these stable molecules constitute the solid material. It is also true that solar radiation will dissociate these molecules which may then recombine to other stable molecules ($2\,H_2O \rightarrow H_2O_2 + H_2$). Explosive chemical reactions between these new molecules are possible and the sudden increases in cometary brightness are attributed to these sources. It is reasonable to propose, however, that the recombination of these free radicals can lead to rather complex molecules with, as yet, unknown chemical properties.

The mechanism for ionization of the molecules is unclear. It is unfortunate that those molecules which radiate well in the ionized state radiate only weakly in the neutral state and vice versa. Thus, the simultaneous observation of the density of ionized and neutral states of a particular molecule, as a function of distance from the nucleus, is not possible. However, there is evidence that no single ionization process is sufficient to account for the observed behavior of the different molecular constituents. The radiated intensity pattern in the coma for CN indicates that the neutral lifetime is in the order of $10^5$ sec, whereas the appearance of $CO^+$ reasonably close to the nucleus indicates a lifetime of only $10^3$ sec for CO. The ionization potentials for both molecules are about 14 ev; the difference in the geometrical appearance of the ionization implies at least an active ionization mechanism in addition to charge-exchange or photo-ionization processes, perhaps chemical in nature. The observed cometary molecular spectra are similar to those observed in low temperature laboratory gases of similar composition; however, the relative intensities of the same band are different. This can be explained if it is assumed that the cometary radiation is the result of solar photo-excitation and the observed intensities are thus modified by the known intensity variations in the solar spectrum.

Two types of comet tails have been observed; although usually only one type is present in any comet, both may occur simultaneously or the tail may be completely absent. One type consists mainly of solid particles and shows a pronounced curvature which indicates the absence of any large solar repulsive force. The light from these tails is reflected sunlight; these tails are characteristic of "new" comets. The other tail type consists of ionized stable molecules identified by their characteristic emission spectrum. These tails show only little curvature indicating a solar repulsive force greater than the attractive solar gravitational force. The ions identified include $CO^+$, $N_2^+$, and $CO_2^+$; the abundance of other ions has not been established. The observation of streamers and filaments with a relatively long lifetime, similar to those observed in a variety of gas discharges in magnetic fields, implies that magnetic fields are associated with cometary phenomena.

It was first believed that the observed steady-state acceleration of the tail could be attributed to the solar radiation pressure. However, calculations by Wurn indicated that the radiation - $CO^+$ cross-section ($CO^+$ is the most abundant observed ion) is too small for radiation pressure to account for the observed accelerations. The correlation, sometimes rather poor, between solar activity and enhanced comet brightness and more violent tail accelerations led Biermann to propose that corpuscular emission from the sun (solar wind) was the source of the observed acceleration. Biermann suggested that charge exchange between the solar plasma and the neutral gas in the coma was the dominant ionization mechanism, and that the tail acceleration resulted from momentum transfers between electrons in the solar plasma and the cometary ions. If reasonable values of the comet tail density were used ($10^3$/cc), densities in the order of $10^5$/cc were required in the solar wind to yield the observed acceleration. Both direct and inferential estimates of the solar wind density indicated an upper limit of about $10^3$/cc for the steady state density; thus Biermann's collisional interaction was too small. However, several possible collective plasma interactions are known which would essentially greatly increase the probability for momentum transfer; these may be of either the electrostatic or hydromagnetic type and are discussed in detail by Hoyle and Harwit.[40, 41] The collisionless electrostatic shock which occurs as a result of unstable plasma oscillation arising from the interaction of two plasma clouds had been postulated by Kahn and Parker and Noerdlinger as a possible source for the observed superthermal particles in the earth's radiation belts. Recent calculation by Noerdlinger[42] and Ek, et al[43] indicate that a high ratio of directed to thermal velocity for both electrons and ions is required for the instability to occur and that the instability proceeds first as an electron-electron interaction followed by the ion-ion interaction. Hoyle and Harwit suggest that the electron-electron instability is possible only in the initial transient interaction between the solar wind and cometary plasma; the result of the instability would be a heating of the cometary electrons so that, in steady state, the instability would not occur. This analysis is probably valid as long as no energy loss process for the cometary electrons can occur so that the electron temperature remains high. Probably collisional loss processes (inelastic collisions) are absent at the low densities. However, radiation might be expected at the plasma frequency ($\sim$1 mc); Scarf[44] had advanced some arguments for the radiation only of the higher harmonics of $f_p$. The observation of low frequency electromagnetic radiation associated with comets is questionable.

Thus in the absence of electron energy loss processes, Hoyle and Harwit conclude that electrostatic instabilities cannot account for the observed tail accelerations and that the interaction must be hydromagnetic. This interaction requires the existence of a cometary magnetic field which Hoyle and Harwit postulate arises in the following manner. It is rather likely that the solar wind retains some trapped magnetic field (circulating currents) since it is presumed to be hydromagnetic in origin. As a result of charge exchange between the relatively stationary cometary neutrals and the solar protons, the solar wind magnetic field is decelerated and trapped in the comet plasma. The interaction of further solar plasma on this trapped field exerts a pressure on the cometary plasma which, with perhaps reasonable assumptions of mass and density, can account for the observed acceleration.

There are several theories for the role of comets in the cosmology of the solar system. It has generally been believed that comets cannot enter the solar system from the galaxy because of the relative absence of hyperbolic orbits; the few observed hyperbolic orbits probably arise as a result of perturbations by Jupiter. Possible sources of comets may be the following: Condensation of portions of the solar nebulae at the time of planet formation, association with the formation of the asteroids, or trapping of material by the sun during passage through a particularly dense and active interstellar cloud. It is quite clear that the lifetime of comets in a small heliocentric orbit is small ($10^5$ years) because of the high rate of material loss and solar disruptive effects. It is also reasonably clear that recondensation or accretion of new material cannot greatly increase cometary life. It is reasonable to assume therefore that a rather large number of comets exist in very large orbits beyond Pluto, where they are not subject to solar effects. These comets are randomly perturbed into observable orbits by the combined effects of the outer planets and perhaps stellar perturbations. The comets represent the principal source for the meteor streams and also perhaps for the interplanetary dust. As a consequence of the Poynting-Robertson effect, the interplanetary dust is swept into the sun, and its replenishment is necessary to maintain the observed steady state conditions.

There is perhaps only one significant piece of information which might suggest an extra-solar system origin for cometary material. The $C^{12}$, $C^{13}$ ratio, as determined by the isotope shift observed in the CN molecular bands, is variable from comet to comet, and ranges from the high values characteristic of the solar system to the low values characteristic of the carbon rich stars. The implication of these observations is rather unclear at present.

Although the comet-meteor stream relationship has been well established, the relationship of comets and meteorites is not as well understood. Since meteorites are, in general, absent from very old deposits in the earth's crust, the general conclusion has been that meteorites are of recent origin as the result of the disintegration of a planet. A relationship between meteorites and comets thus also infers a recent origin for the comets. It is possible that, as a result of a planet's disintegration, material may have been distributed into distant orbits; however, the solid material would probably be rather large in size and this conflicts to a degree with Whipple's icy conglomerate comet model and does not explain the origin of the required gas reservoirs.

## B. COMET INTERCEPT EXPERIMENTS

It is pertinent to ask what information might be desirable to obtain a more complete understanding of the physical and chemical nature of comets and their interaction with their environment, and whether a suitably instrumented flight in the near vicinity of a comet could yield important information. In the following sections a number of possible experiments are discussed which could be included into a space-probe payload at the present time, i.e., with existing instruments and technology. The final sections contain a discussion of significant measurements that might be included as future comet probe experiments. It must be pointed out that, in general, a single experiment or measurement, while contributing to the general scientific knowledge of comets, will not in itself necessarily resolve any of the basic outstanding questions of cometary phenomena. These basic categories are concerned with 1) structure, 2) plasma interactions, and 3) chemical composition. Some currently possible experiments appropriate to each are discussed below.

### 1. Comet Structure Experiments

a. Television. Undoubtedly, photography of the nucleus from short distances would be valuable in confirming the icy conglomerate model, and in confirming present ideas of the nuclear size and mass. If we assume that the encounter between the probe and the comet occurs at 1 AU from the sun and that the nucleus of the comet is visible by reflected sunlight with a 10-percent reflectivity, then the total energy flux per unit area reflected by the nucleus is $1.4 \times 10^5$ ergs/cm$^2$/sec over all wavelengths. If we further assume a miss distance of $10^4$ km and treat the nucleus as a sphere of radius R cm, then the energy flux entering an objective lens of diameter D cm will be given by

$$\frac{1.4 \times 10^5 \cdot 4\pi R^2}{4\pi \times (10^9)^2} \cdot \frac{\pi D^2}{4} = 1.1\, R^2 D^2 \times 10^{-13} \text{ ergs/sec}$$

If the lens transmits 50 percent of the energy falling on it then the energy flux per resolution element incident on the photocathode of the television camera tube will be $5.5\, R^2 D^2 \times 10^{-14}$ ergs/sec. Of the total reflected solar energy incident on the TV tube cathode, only a fraction is effective due to the spectral response of the photocathode. If we choose the interval from 3000 Å to 6500 Å, this represents about 43 percent of the solar energy flux. Thus the effective flux on the TV tube is $2.36\ R^2D^2 \times 10^{-14}$ ergs/sec.

Let us choose a telescope such as the Questar, whose physical dimensions are easily incorporated into a space-probe payload. This instrument has a focal length of 120 cm and an aperture of F/11. The diameter of the image then will be $2.4\ R \times 10^{-7}$ cm. Let us now assume a nuclear radius of 1 km = $10^5$ cm. Then the image diameter equals $2.4 \times 10^{-2}$ cm and the image area equals

$$\frac{\pi(2.4)^2 \times 10^{-4}}{4},\ 4.52 \times 10^{-4}\ \text{cm}^2$$

The television system will probably require some kind of storage prior to telemetry readout. Therefore, a storage videcon pick-up tube is suggested. The best resolution that can be achieved is about 1000 lines/in. at $10^{-2}$ ft-candles illumination and with 1/30 second integration time. This means a minimum energy density of $2.93 \times 10^{-2}$ erg/cm$^2$ is needed. From the above image area a minimum total energy of $(4.52 \times 10^{-4})\ (2.93 \times 10^{-2}) = 1.325 \times 10^{-5}$ ergs must fall on the photocathode. This in turn will require an exposure time of $2.36\ R^2D^2 \times 10^{-14}$ seconds. The effective diameter of the lens is given by $D = \frac{f}{F}$ where f is the focal length and F is the f-number. Then $D = \frac{120}{11} = 10.9$ cm. For $R = 10^5$ cm, the minimum exposure time is $4.72 \times 10^{-4}$ seconds.

Now 1000 lines/inch resolution means resolution elements of about $6.45 \times 10^{-6}$ cm$^2$. Therefore, the image will cover

$$\frac{4.52 \times 10^{-4}}{6.45 \times 10^{-6}} = 70$$

resolution elements. The area of the nucleus treated as a circular disc is $\pi R^2 = 3.14 \times 10^{10}$ cm$^2$ so that we resolve elements of surface area equal to $\frac{3.14 \times 10^{10}}{70} = 4.5 \times 10^8$ cm$^2$. This corresponds to linear elements on the comet of $2.1 \times 10^4$ cm or 0.21 km. The only way this can be improved is to use a longer focal length lens or achieve a miss distance less than $10^4$ km.

The above calculations have been based on an attitude-controlled, non-spinning vehicle such that the videcon tube can view the comet for at least $4.72 \times 10^{-4}$ seconds with negligible lateral displacement of the image. Suppose now that the vehicle is spinning at 2 revolutions/sec and that the look direction is at right angles to the spin axis. In $4.72 \times 10^{-4}$ seconds, then, the camera will sweep out $4\pi \times 4.72 \times 10^{-4} = 5.93 \times 10^{-3}$ radians. At $10^4$ km, there are $10^{-4}$ radians/km so in the time required for the exposure we sweep out $5.93 \times 10 = 59.3$ km, which of course completely smears out the image.

In general, distance swept out in km $= 0.493\ \omega$ where $\omega$ is revolutions/min. The resultant resolution, in km, due to the lateral motion superimposed on the intrinsic resolution of the system, is given by $\sqrt{(.21)^2 + (.493\omega)^2}$. If we accept a final resolution of .3 km, then $\omega = .43$ revolutions/minute. If it is not desirable to de-spin this much or less, then of course much detail of the nuclear surface is lost.

The telemetry problem does not appear too difficult since only about 70 resolution elements are involved with, say, 5 levels of grey.. This would be 350 bits of information per picture. This information could be placed in a buffer storage and additional pictures could then probably be taken. It may also be of interest to obtain pictures in different wavelength regions by using filters. If we take, say, four pictures at 15-minute intervals, then the telemetry rate would be only about 1/3 per second. Let us then assign 1 bit/sec for the television.

Due to the fact that at $10^4$ km the image of the nucleus only occupies a small fraction of the available television field, a sensing error of $\pm 10^{-2}$ radians from the probe-nucleus vector would still allow the image of the nucleus to fall on the television tube cathode. Some kind of optical sensing device will be necessary to locate the optical center of gravity of the comet which is presumably the location of the nucleus. After a sufficient time for tracking and scanning by the sensor, the television camera would be turned on and the picture recorded.

A ruggedized television camera with a slow scan videcon tube, such as has been developed by Hallamore Electronics, would represent a typical system. Such a unit would weigh 7 pounds and consume about 9 watts of power.

b. Micrometeorite Experiment. Measurements of the abundance and mass of the solid particles in the coma would contribute to a knowledge of the nuclear structure and also possibly to the knowledge of meteor streams. Since the polarization and intensity of the continuum portion of the cometary spectra, as observed by terrestrial telescopes, depends on the nature, size distribution, and shape of the scattering particles, any information pertaining to these parameters would greatly enhance the interpretation of the spectrum.

Many types of micrometeorite and dust particle detectors have been developed and flown in the past so that the "state-of-the-art" is well developed. If we choose a comet such as 1957c (Encke), then the dust density as estimated from the intensity of the continuum is $10^{-9}/cm^3$ at 4 - 9 x $10^4$km. Assuming a relative velocity of 15 km/sec between the probe and the comet, then, with a detector of area 350 $cm^2$ we could expect about one impact every two seconds. A minimum momentum impact sensitivity of $10^{-5}$ dyne-sec would detect particles of mass about 7 x $10^{-12}$ grams at the above velocity. If these are spherical iron particles, this results in a minimum radius of about 0.6 micron. A micrometeorite detector such as the one being flown by Alexander on OGO has this order of sensitivity and is capable of measuring any charge which may reside on the particles as well as both the momentum and the energy of the particles. The velocity is determined by a time of flight measurement which is accurate to about 1.5 percent. The information to be read out would be velocity, momentum, charge, and total number of impacts. These could probably all be contained in one 9-bit digital word resulting in a telemetry rate of about 5 bits/second. This type of experiment would weigh less than 10 pounds and consume less than 1 watt of power.

2. Plasma Interaction Experiments

It is doubtful whether measurements of this type in the tail can, in themselves, lead to a complete understanding of the observed accelerations. It is believed that more detailed measurements of the tail properties can, however, distinguish between the electrostatic and hydromagnetic plasma interaction possibilities and also provide a more rigorous test of the various present theories. The significant parameters would be ion density, electron temperature, and the vector magnetic field.

a. Plasma Probe. By measuring the electron temperature, by means of, for instance, a planar ion and electron trap, a great deal could be learned about the interaction between the solar wind and the cometary plasma. In particular, this experiment should be able to resolve the question as to whether the acceleration of ions into the tail is due to electrostatic instabilities in the plasma or whether the interaction is hydromagnetic in origin. In addition, measurements of the solar wind while en route to the comet would be invaluable.

An ion and electron trap such as the one being developed by Whipple for OGO is capable of measuring the density and temperature of thermal electrons as well as densities, masses, and temperature of thermal ions. Such an instrument is capable of detecting positive or negative currents as small as $10^{-13}$ amps. This corresponds to $6.25 \times 10^{5}$ electrons/sec. With a relative velocity of 15 km/sec between the probe and the comet and assuming a 20 $cm^2$ detector area, the minimum detectable electron density would be $2 \times 10^{-2}$ electrons/$cm^3$ and similarly for the positive singly charged ions. The information to be read out would be a digital voltage word for each of four electrodes and a digital current word for the electrometer for a total of 45 bits at each sampling. If we sample once per second, then the rate must be 45 bits/sec. The weight of the entire experiment would be about 5-8 pounds and would require about 2 watts of power.

b. Magnetic Fields. Many magnetometers have been flown on satellites and space probes in the past and the state-of-the-art is well advanced to the point where no problems should be expected with placing a magnetometer aboard a comet probe. One would want to measure the vector magnetic field both in interplanetary space and as the probe approached, passed through, and receded from the comet. The magnetometer should have a sensitivity on the order of one gamma or less since this is the order of magnitude of cometary magnetic fields that have been postulated in order to explain certain molecular ionization phenomena and plasma interactions.

A triaxial flux gate magnetometer along with a rubidium vapor magnetometer, so as to obtain independently both the components and the absolute magnitude of the magnetic field, would eliminate the principal disadvantages of either instrument alone. If we assume a range of 0.1 to 3.2 gamma in 0.1 gamma steps, then we need 6 digital bits for each of the flux gate components plus an additional 6 bits for the rubidium vapor information. Thus, a total of 24 bits per sampling is required. If we sample twice per second, then the rate is 48 bits/sec. The weight of such a package including electronics would be about 13 pounds and the total power consumption about 8 watts.

c. Contamination Experiment. A third possibility which should be included under plasma interactions would be to contaminate the comet with a suitable substance released from the probe in the vicinity of the comet. If, as is believed, there exists a cometary magnetic field of the order of a few gamma, then the ions produced by photoionization of the contaminant material could become trapped by the field. The observation from the earth of the solar radiation resonantly scattered by these ions could provide some useful information on the nature of the forces involved and the interactions between the ions and the solar wind. As pointed out by Münch, the lifetime of the phenomena, or the time available for observation, is a function of the mass of contaminant and explicitly $t = \frac{M}{4.55}$ where M is in kilograms and t is in days. Thus, a mass of contaminant on the order of 23 kilograms or 51 pounds would result in the ability to observe the motion over a period of 5 days. This is, of course, much longer than an instrumented probe would remain in the vicinity of a comet. Therefore, the contamination experiment is a possible way to study the large scale dynamics of cometary ions.

## 3. Chemical Composition Experiments

Because of the extended size of the coma and tail, the emitted light intensity would not be increased significantly on close approach so that no appreciable increase in spectral sensitivity could be achieved. It is also presumed that, in the near future, it will be possible to perform spectroscope observations above the earth's atmosphere, thus enabling access to the UV region. Thus, it appears that the only spectroscopic gain in a near approach would be an increase in the geometrical resolution and it is questionable as to whether this is necessary. A more rewarding series of experiments directed toward the identification of cometary compounds and the ionization dissociation processes is possible in the coma. Presumably the parent molecules are abundant only in the near vicinity of the nucleus. In general, the spectroscopy of polyatomic molecules is complicated and the laboratory spectra for these molecules are not well known. Thus, it would appear that spectroscopic identification of the parents is insufficient and that mass analysis represents the most feasible approach. Some conclusions with respect to dissociation processes can be obtained by observation of the molecular mass distribution as a function of distance from the nucleus. A measurement of the percentage ionization as a function of distance from the nucleus would provide valuable confirmation of the spectroscopic data; even more significant would be the determination of the percentage ionization for the individual molecules which could lead to the proper interpretation of the various ionization mechanisms.

a. <u>Mass Spectrometer</u>. Ion mass spectrometers are currently being developed which will have sensitivities down to $10^{-14}$ amperes. This corresponds to a flux of singly charged ions of $6.25 \times 10^4$ ions/sec. For a window area of 12 $cm^2$ and a relative velocity of 15 km/sec, the minimum measurable density will be about $3.5 \times 10^{-3}$ ions/$cm^3$. Unfortunately, it is very difficult at the present time to perform a mass analysis of the neutral molecules since the efficiency for ionization by an electron beam is on the order of only 1 in 40,000. However, the relative abundances of the ionized molecules could be measured by this method and this in itself would be a significant experiment. An rf ion spectrometer such as the one being developed by Taylor for OGO is capable of measuring positive ion masses from 1 to 45 amu. This range includes all of the molecular ions that have been observed spectroscopically. From 1 to 6 amu the resolution is 0.5 amu and from 7 to 45 amu the average resolution will be 1 amu. The information sought here will be in the form of an ion current converted to a proportional voltage by the electrometer tubes. Different masses are analyzed and allowed to impinge on a collector electrode by appropriately varying certain grid voltages. Since it is not known definitely a priori just what ion species to expect, the remaining available telemetry should be assigned to this experiment. If the total telemetry capability is 250 bits/sec, then the mass spectrometer would use 151 bits/sec. The total instrument including two spectrometer tubes weighs about 8 pounds, occupies about 1 cubic foot, and consumes about 8 watts of power.

## 4. Summary of Proposed Payload Experiments

The following table summarizes the weights and power of the presently feasible experiments which could be included as a comet probe payload.

Table 3-1. Weights and Power of Experiments

| Experiment | Weight (lbs) | Power (Watts) | Telemetry Rate (bits/sec) |
|---|---|---|---|
| TV | 7 | (9 - at the comet during operation) | 1 |
| Micro-meteorite | 10 | 1 | 5 |
| Plasma Probe | 8 | 2 | 45 |
| Magnetometer | 13 | 6 | 48 |
| Mass Spectrometer | 8 | (8 - at the comet intermittently) | 151 |
| Total | 46 (lbs) | 9 (average watts) | 250 (bits/sec) |

Thus, with the exception of the contamination experiment which would increase the weight by about 50 pounds, the five experiments above would have a combined weight of 46 pounds and a total power consumption of about 28 watts.

## 5. Possible Future Experiments

It is clear that experiments which can be performed with present "state-of-the-art" techniques yield no information whatsoever with respect to the cosmological significance of comets and only limited information with respect to the radiation chemistry and molecular configuration of cometary material. This section will discuss some of the problems involved and will outline some possible experimental approaches for consideration in future experiments. The ideal future experiment would consist of a landing on the nucleus, sampling of nuclear material, and return of the sample to earth for analysis. If we confine this experiment to the far-distant future, there are however other experiments which may be considered.

a. Elemental Analysis. The elemental constitution of the solid fragments would be most important in establishing the origin of cometary material. The collection and analysis of the micrometeorite fragments could be a reasonable approach to this problem. It is clear, of course, that because of the small sample size fractionation effects during formation would be of major importance and probably only elements with very similar physical properties might coexist in the sample. A reasonable method of analysis might be through neutron activation and subsequent analysis of the activation spectrum. This experiment implies that the isotopic abundances of the studied elements would require an irradiation time of about 1 hour to yield detectable activities. This appears marginally feasible at best with conventional neutron sources, but should be considered as possible.

b. Isotopic Analysis. Isotopic abundances which could yield information with respect to the time of fragment formation is clearly more difficult. This is further complicated because of cosmic ray bombardment of the small samples so that the isotopic abundances no longer reflect the time of formation. However, if possible, this would be an interesting experiment.

c. Radiation and Radio Chemistry. The radioactivity expected to be associated with the small solid samples arises from cosmic ray bombardment. The cosmological interpretation of these radiations is doubtful, but rather interesting radio chemical information may be obtained.

d. Neutral Particle Mass Spectrum. The important radiation chemistry problems would involve a study of the parent molecules sublimed from the nucleus and a direct determination of the ratio of ionized to unionized abundance of a given molecule. It is believed that ion mass spectroscopy is feasible in the coma and tail. However, the mass spectroscopy of neutral molecules is more difficult because of the low efficiency of ionization. The development of neutral particle mass spectrometers for particle densities less than $10^6$/cc remains to be done.

6. The Comet As Its Own Experimental Source

To this point the experiments and detection sensors considered all have been restricted to more-or-less conventional means of data elicitation and gathering in space experimentation. However, another approach, similar in some respects to the contamination experiment, is to place all of the complex measurement equipment on the ground and enhance the visible characteristics of the comet. The most effective way of doing this is simply to transport a nuclear weapon to the comet, detonate it on command, and sense and record the resulting phenomena from earth-bound stations employing sensitive observational equipment. The simplest version of this scheme would dispense with on-board scientific instrumentation and associated data storage, described in later sections, and use the additional mass capability of the spacecraft to transport the weapon. In this way, the resolution of the detection equipment can be chosen as great as is consistent with the technology of earth-bound astronomical observational equipment, without regard for equipment mass or size.

The physical facts which make such a scheme appear interesting are:

a) A very large mass of cometary material will interact with bomb plasma and radiation, even a relatively low yield bomb. Typically, the mass of ambient material which will be affected (in ways useful for our purposes) by nuclear radiations and/or by kinetic energy of the device following burst may be 100 to 1000 times that of the device itself. In effect this yields an experiment with 100 or more times the mass of a contaminant which could be carried by the spacecraft, and the "contaminant" is material (neutral as well as ionized species) of the comet itself.

b) Extensive electronic excitation will take place and provide intense, distributed, and relatively long-lived sources of photon radiation. These can be exploited by space-resolved, time-resolved, as well as general spectroscopy to provide a wealth of information on chemical composition, distribution and density of neutral species, and cometary structure, and some data on plasma interactions.

c) Large-scale motion of considerable masses of energetic plasma will occur as bomb plasma or "debris" interacts with cometary matter and magnetic fields. Direct photography as well as high-resolution time-resolved spectroscopy can be used to determine the details of this motion, and results of such measurements could provide both direct and deductible information about magnetic field strengths and structure, plasma interactions within the comet, and cometary mass structure.

d) The great increase in electron density caused by the release and distribution of the weapon energy could provide an observable source of radio emissions at cyclotron frequencies in the local magnetic field. Measurement of signal amplitude/frequency distribution with large and sensitive earth-bound radio telescopes would (in conjunction with other data) provide further information on atom densities, temperatures, and magnetic field strengths.

The possibilities of this experiment have not been analyzed in any detail here; however, some simple numerical considerations are presented in Appendix C to illustrate several possibilities for experimentation.

The utility of this method of comet exploration depends in large measure on the energy yield which can be released by the nuclear device, since this sets the level of source strength and hence determines the detectability (or otherwise) of signals here on earth. Brief unclassified considerations lead to a belief that quite adequate payload capability is available; more detailed study should include basic data on weapon masses and yields. It is also worth noting that this use of nuclear weapons for peaceful, scientific purposes could perhaps provide a test or check of high altitude weapons test detection systems now under development.

## 7. Some Scientific Constraints on Mission Requirements

In this section we shall examine some specific comets in greater detail with particular regard to which comets seem most suitable to investigate with the proposed experiments and how the scientific results are affected as a function of miss distance.

It must be understood, at the outset, that numbers pertaining to cometary dimensions, ion and dust densities, and other physical properties of comets that have been deduced from terrestrial observations, are at best only order-of-magnitude values. These numbers will vary considerably, of course, depending on which specific assumptions one imposes on the comet and which interpretation one gives to the experimental observations.

As was already pointed out, a comet, in general, can be divided into three physical regions: the nucleus, the coma, and the tail. The nucleus probably consists of frozen gases interspersed with solid micrometeorite particles ("icy conglomerate" model) and has a diameter on the order of several kilometers. As the comet approaches the sun, the material at the surface of the nucleus sublimes as a result of the effect of the solar radiation. The density of sublimed gases and particles increases as the heliocentric distance decreases. These materials form the coma and are responsible for the observed molecular emission spectra, the brightness increasing as the comet approaches perihelion. The dimensions of the coma are different when viewed in different regions of the spectrum, indicated a non-uniform distribution of molecular species. In general, the coma extends from $10^4$ - $10^5$ kilometers in diameter. The molecules in the coma are neutral free radicals that have been dissociated from stable parent molecules as well as ionized species.

The third region, the tail, consists primarily of ionized stable molecules and small solid particles. The dimensions of the tail are perhaps $10^6$ kilometers long and $10^4$ kilometers wide. Not all of the proposed experiments could be best accomplished in only one of these regions. We shall first specify the particular region of interest for each experiment.

The television picture, of course, is concerned with the solid nucleus. The micrometeorite experiment would deal principally with the coma. The plasma probe and magnetometer would be most useful in the tail but important information could also be obtained in the coma. Finally, the ion mass spectrometer would probably be most useful in the coma since something might then be said about the neutral molecules from a measurement of the ion densities in this region. This, of course, does not rule out the possibility that significant results might be obtained in the tail.

Let us now look at a few specific "typical" comets for which molecular ion and dust density estimates have been made. From photoelectric and spectroscopic observations of Encke (1957c) and Giacobini-Zinner (1959b), the density of $CO^+$ molecules near the head ($\sim 10^4$km) is of the order of 1 to 100 molecules/cm$^3$. The average dust densities for these comets are of the order of $10^{-19}$ to $10^{-24}$ gm/cm$^3$. For comet Arend-Roland (1956b) the dust densities are of the order of $10^{-11}$ to $10^{-14}$ gm/$cm^3$. It can be seen that not only are these densities very small but the estimates range over many orders of magnitude. For a micrometeorite detector with a minimum sensitivity of $10^{-5}$ dyne-sec, and a relative velocity of 15 km/sec between the probe and the comet, one could detect spherical iron particles of minimum radius 0.6 microns or spherical $CO_2$ particles of minimum radius 1.0 micron. From the intensity of the continuum and certain assumptions regarding the number and density of the solid particles, the radius of the particles is believed to be of the order of 0.5 microns. If the area of the detector is 350 $cm^2$ then the number of impacts per second = $5 \times 10^8 \rho$ where $\rho$ is the dust density in particles/$cm^3$. For comparison, the dust density of Encke is believed to be $\sim 10^{-9}$ particles/$cm^3$ and for a "dusty" comet, such as Giacobini-Zinner, it is $\sim 10^{-7}$ particles/$cm^3$. Thus, the impact rates seem reasonable as long as the momentum is sufficient.

As with molecular and dust densities the dimensions of cometary nuclei are subject to considerable uncertainties. Most estimates of nuclear radii are based on observations of visual magnitudes. To convert this information to a nuclear radius requires a knowledge of the albedo, A. We do not know the value of A for cometary nuclei. The lowest value ever observed on astronomical objects is 0.028 (for Ceres) and the highest one is 0.61 (for Venus). These maximum and minimum values result in the following radii:

Encke (1957c) 0.67-4 km
Halley-Peltier (1936a) 25-60 km
Giacobini-Zinner (1959b) 0.72-4.6 km
Mrkos (1957d) 3.93-232 km
Bester (1948I) 7-41 km
Winnecke (1927) 0.17-0.80 km
Bappu (1949c) 8.3-36 km

For a miss distance of $10^4$ km we could obtain a resolution of 0.2 km at the surface of the nucleus with the system described in section B.1.a. This should be sufficient to resolve some structure for most nuclei. There can be no doubt, in general, that in order to make any significant measurements with the presently proposed experiments, the probe must penetrate the coma to at least 10 percent of the distance to the nucleus. This means a miss distance of less than $10^4$ km. In addition, in order to learn something of the dynamics involved in the tail from the plasma probe and magnetometer, the probe must also pass through the tail. As far as the experiments themselves are concerned, there is no particular reason to prefer one comet to another except perhaps one whose motion is retrograde, such as Halley's or Temple-Tuttle which would thereby increase the probe-comet relative velocity as well as enabling the probe to traverse the tail longitudinally.

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60. Magnolia, L. R., "Interplanetary Matter: A Bibliography," ASTIA No. AD 276064, Space Technology Laboratories No. 9990-6058-KU-000 (June, 1962).

61. Ibid, 1962 Supplement (April, 1963).

# IV. REQUIREMENTS FOR A MISSION TO A COMET

This section discusses first the general requirements for a mission to a comet and then describes the specific requirements for each of the comets studied.

Under the general requirements, the overall problems concerned with the trajectory of the spacecraft from the earth to the comet, the injection velocity requirements, the approach velocities, and the miss at impact for a given set of injection errors for given launch dates and flight times are described. Secondly, the accuracy requirements, both in terms of our knowledge of the orbit of the comet and in terms of the requirements upon the spacecraft, are given. The payload capabilities of a range of boosters, emphasizing current relatively low cost boosters are given. We then discuss some of the problems associated with the logistics of the launch of the entire booster and spacecraft. At this point the requirements of the spacecraft and its subsystems suitable for this mission are given. And finally some general considerations concerning the reliability requirements for typical comet trajectories are also described.

The second subsection describes these requirements in terms of specific comets. These are arranged by comet in order of the comet period about the sun.

## A. GENERAL COMET MISSION REQUIREMENTS

### 1. Overall Characteristics of Trajectories from the Earth to the Comet

The first step in selecting a trajectory to a comet is to determine the injection velocity requirements since this sizes the booster. Since existing boosters, which have a limited payload capability, are considered for this study, only the lowest energy transfer trajectories may be used. These are a function of the synodic period of the earth and the comet. However, a certain amount of time for launch, conventionally called the "launch window," is required. Hence, "the" minimum energy trajectory to the comet cannot be used since a month or two is needed for this launch.

A plot of minimum energy per launch day, for trajectories for a mission to the comet Encke in 1964, is shown in Figure 4-1. As can be seen, the minimum energy trajectory possible, injection velocity of 40,000 fps at 22,000,000 feet altitude (177 n mi), occurs in October 1963 and March 1964. If a 2-month launch window is allowed, a velocity of 44,000 fps is required. And if the launch window is made larger, an even greater velocity range is needed. Two curves are shown—one which corresponds to trajectories which take us less than 180 degrees heliocentric longitude, called "Class I," and one which is greater than 180 degrees, called "Class II." In general, a 180-degree transfer trajectory requires very high velocities since the plane of that trajectory (which is fixed by the position of the earth at launch, the sun, and the position of the comet at intercept) is normally very highly inclined to the orbit of the earth, and thus very little use can be made of the velocity of the earth in its orbit about the sun. Therefore, there are usually two classes of low-energy trajectories separated by the 180-degree mark. Useful as these curves of minimum energy are, an even more helpful curve is the one that has been used throughout this report. It shows contours of injection velocities as functions of flight time and launch date, since flight time is also one of the key criteria in evaluating a spacecraft mission because it determines the minimum lifetime requirement for the spacecraft.

Figure 4-2 shows contours of injection velocity at 177 n mi altitude for comet Encke in 1964. (Although velocity is referenced to a 177 n mi injection altitude, the equivalent velocity at any other injection altitude can easily be obtained by use of the energy equation.) Also plotted on this curve is the transmission distance at arrival in nautical miles. These diagonal lines correspond to fixed arrival dates. Communication distance is important since it is a factor in determining the power system requirement. (This transmission distance includes the out-of-plane effects of the trajectory.)

The velocity contours show a number of interesting properties. If we examine the velocity contours for the trajectories which have a heliocentric angle greater than 180 degrees, injection velocities from 40,000 fps up to 60,000 fps are shown. The region of principal interest to us, that under 50,000 fps, has a very regular contour. However, for this class of

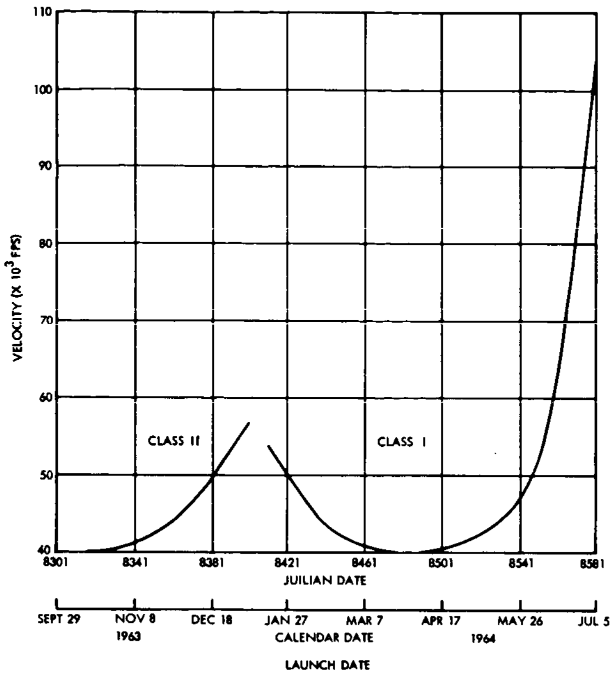


Figure 4-1. Minimum Energy for Launch Date to Encke, 1964

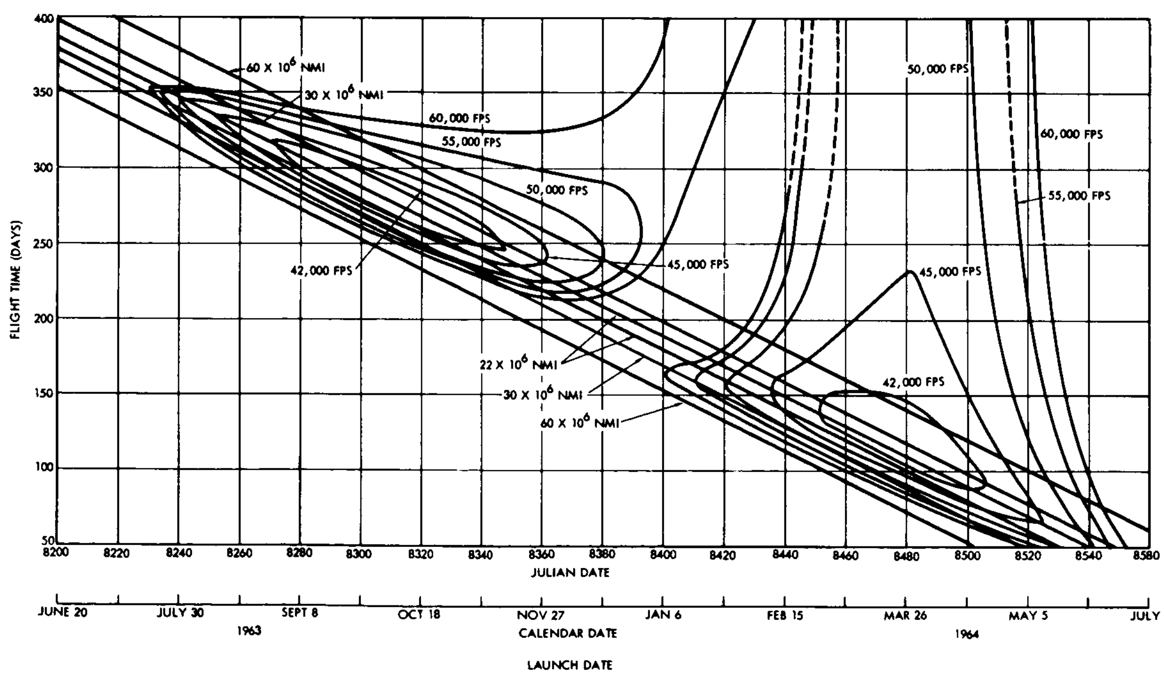


Figure 4-2. Contours of Velocity for Flight Time and Launch Date, Encke, 1964

trajectories in the 42, 000 fps region, the minimum flight time is in the order of 250 days and the maximum about 320 days. The launch window runs from about August 30 to October 30, a period of two months. If the booster can provide 45, 000 fps of injection velocity with the required payload, it is possible to launch between August 10 and November 30. Although this window is perfectly adequate, the long flight times make this class of trajectories undesirable.

For Class I velocity contours, 42,000 fps permits a flight time as short as 90 days and as long as 150 days. The launch window at this velocity runs from February 26 to April 21, a period of two months, which is satisfactory. The transmission distance for both classes in the 42, 000 fps region is 22 million miles (which is to say that the arrival date is the same), a modest communication requirement similar to the typical short communication distance to Venus. However, these contours show a peculiar property which is not seen in interplanetary trajectories, that is the peculiar vertical characteristics of the contour above 45, 000 fps for Class I trajectories. With an injection velocity of 50, 000 fps, and a launch date in the middle of March, the flight time appears to be indefinite, running from as low as 60 days up in excess of 400 days. This property arises from the eccentricity picture of Encke's orbit and the launch date possible. Figure 4-3 shows these characteristics of the launch to Encke in March 1964. For a launch in March with a given velocity, the flight time can be changed substantially simply by changing the direction of our velocity vector a small amount as it leaves the earth. This is possible because a small change in the direction at earth allows the spacecraft to move up and down the essentially flat path of Encke's orbit. Thus, with a single velocity, the flight time can be changed enormously. Although, of course, we are primarily interested in short flight times and hence these long flight times are of academic interest, this property has an effect in the terminal phase of the trajectory which is of considerable interest and is discussed later.

Figure 4-4 shows the closing velocity of the spacecraft and comet for the same parameters, that is launch date and flight time. Closing velocities are, of course, of great interest since they show how long the spacecraft is in the comet itself and thus helps design the experimental

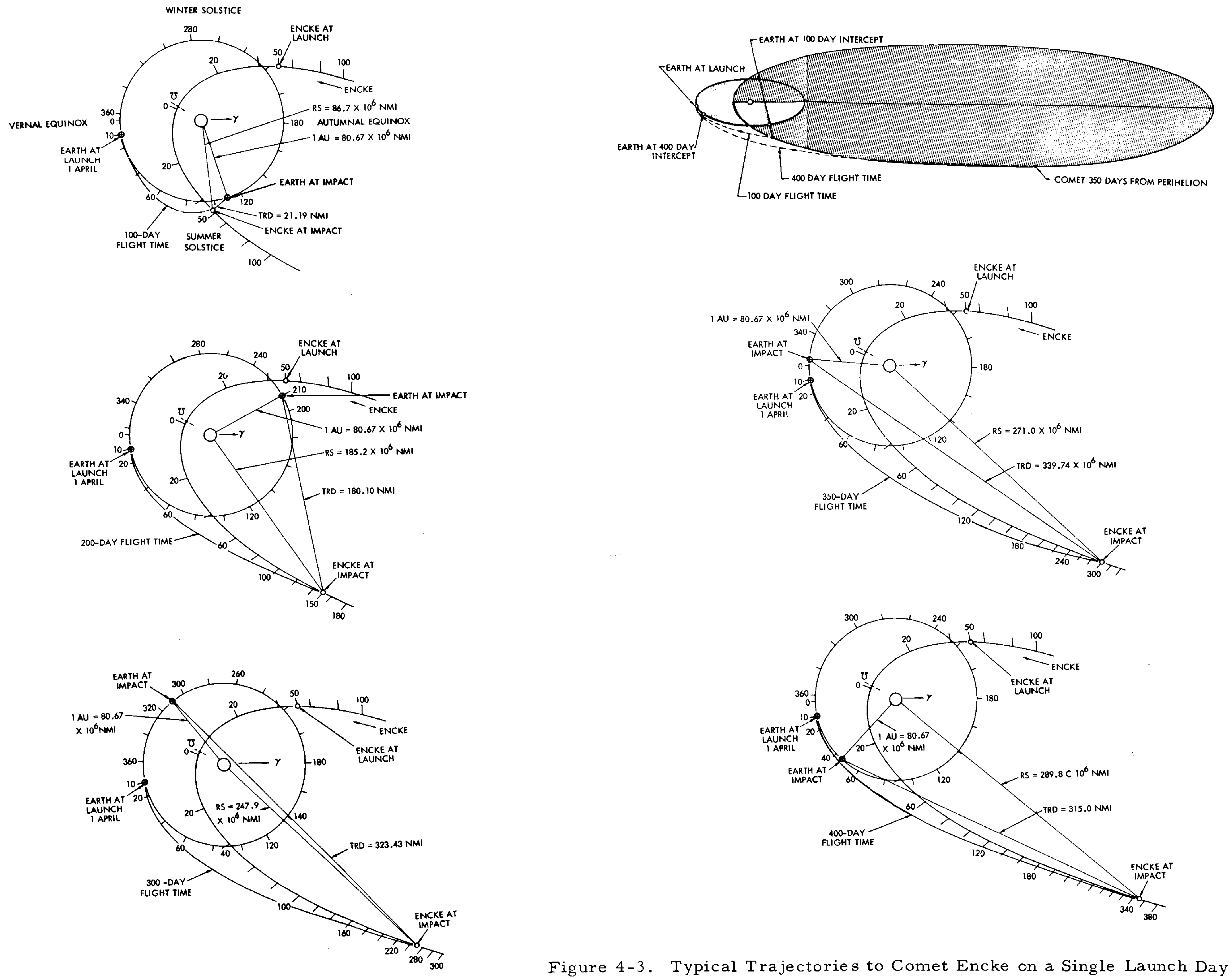


Figure 4-3. Typical Trajectories to Comet Encke on a Single Launch Day

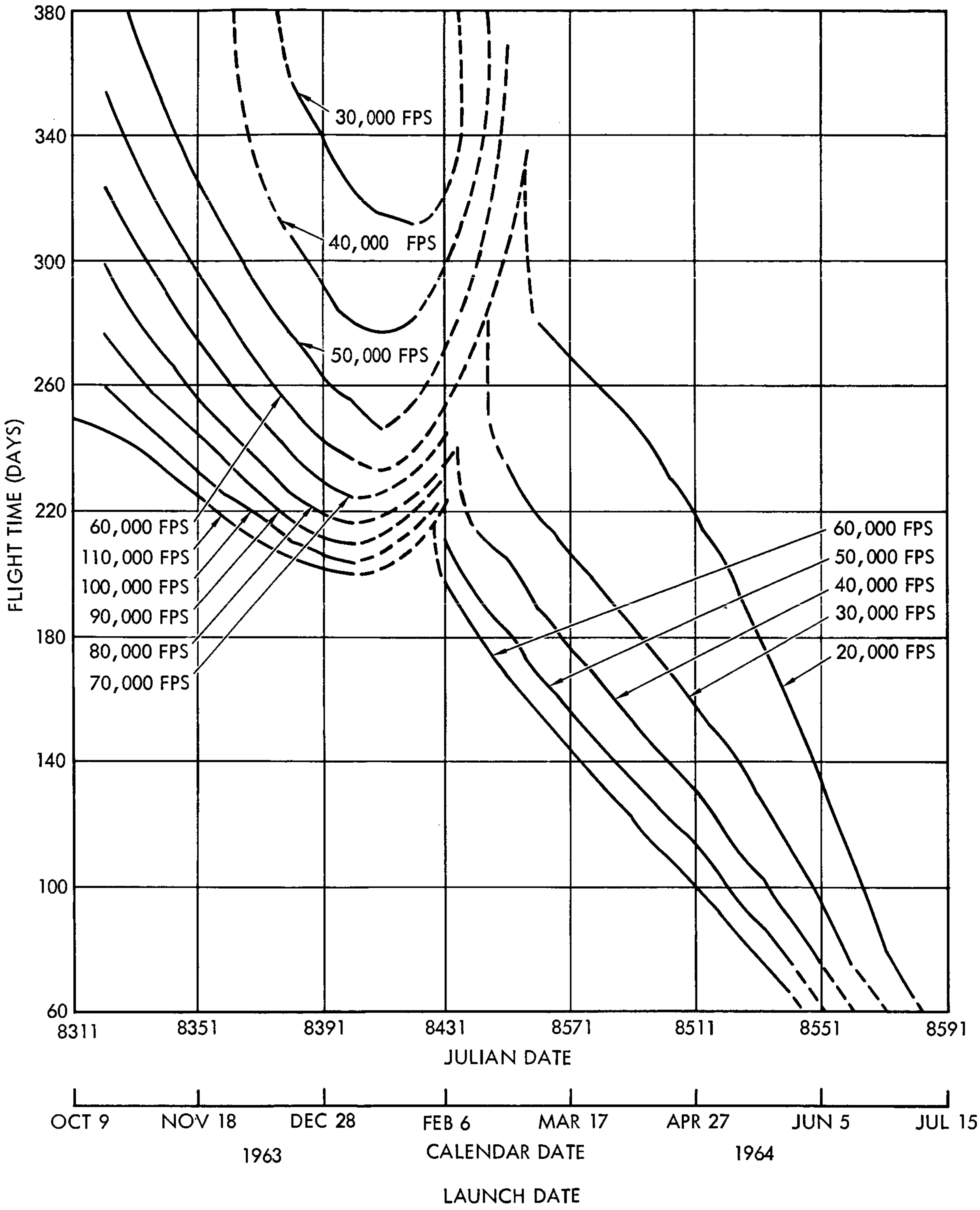


Figure 4-4. Closing Velocity Between Spacecraft and Comet for Flight Time and Launch Date, Encke, 1964

instruments to be used. As can be seen, the closing velocity ranges from as little as 12,000 fps up to 100,000 fps. This velocity, of course, depends on two major factors, the velocities of both the spacecraft and the comet on one hand and the angle between the velocity vectors on the other. A large intercept angle, of course, causes a relatively high closing velocity.

If Figure 4-2 is compared with Figure 4-3, the regions of high closing velocities can be estimated; thus, for a launch in the plane of the comet, the intercept angle will generally be smaller especially on long flight time trajectories. A launch about the first of March, which approximately corresponds to the location of the descending node of the comet of the plane of the ecliptic will tend to minimize closing velocity and the slowest closing velocity should occur when both the spacecraft velocity and the comet velocities are relatively low and the intercept angle small. For the range of cases examined then, minimum closing velocities should occur for about 400 days flight time and launches near the first of March. Launches on any other date will show a gradual increase in approach velocity since the spacecraft will be out of the plane of the comet and have a larger closing angle. And this is what is shown—the very long flight times give very low approach velocities, and launches near the first of March give the lowest of these.

This condition is obviously quite sensitive to the synodic period since the likelihood of being able to launch in the plane of the comet at such a time that the comet can be intercepted with reasonable injection velocity is not frequently possible. However, in general, the key element is not the closing angle but the low inertial velocities of both the comet and the spacecraft near the aphelion of their trajectories. But these very low relative velocities only occur on very long flight times, which are undesirable. Rather, this in-plane effect should be exploited on the relatively short transfer trajectories. The lowest achievable approach velocities should occur for launches near the first of March for the relatively short trip times in the order of 100 to 150 days, and indeed, this is the case. (See Figure 4-4 .) Thus, a launch in March 1965 would appear to be very desirable both from the point of view of minimum injection energy, minimum flight time and minimum approach velocity, and minimum transmission distance. However, as pointed out in Section III, a minimum approach velocity is not necessarily desirable since some of the scientific instruments carried depend upon fairly high closing velocities to sense properties being evaluated. Nevertheless, a desirable objective for some experiments is that they be in this comet for as long as possible. This can only occur with relatively low closing velocities. Moreover, another fact is that to make a terminal correction to insure that a close miss of the nucleus, or to make a correction to change time the spacecraft is in the comet, a low relative velocity is desirable since a reasonable impulse from a spacecraft propulsion system can perform this maneuver very effectively.

In general then, it may be said that a launch near March 1965 allows a reasonable injection velocity and gives a high probability of mission success with a good potential for trajectory modification to improve our experimental data results.

Having selected a launch time, it is important that we consider the precise conditions at injection, since it is not always possible to achieve all necessary launch conditions from a given launch site without violating range safety requirements. A key parameter in selecting a launch site is the declination of the $V_{infinity}$ vector which sets the inclination of the coast orbit which, in turn, sets launch azimuth. Figure 4-5 shows the declination of the $V_{infinity}$ vector for the various launch dates as a function of the flight time. For flight times of 80 to 200 days — the region of greatest interest — the declinations range from +20 degrees to more than -80 degrees. Figure 4-6 shows contours of azimuth, A, and the total inflight angle, $\theta$, for the various declinations of the $V_{infinity}$ vector as a function of the available launch window for a launch from Cape Canaveral. The cross-hatch region shows the generally acceptable range-safe azimuths from AMR, which are between 80 to 120 degrees. With this allowable azimuth, our maximum declination is about $\pm 42$ degrees. Thus, a launch from Cape Canaveral is bounded by this declination. Turning back to Figure 4-5, we see that launch cannot occur before March 22 since declinations associated with these launch dates have either too short or too long a flight time with an acceptable declination. However, it is clear that the spacecraft can be launched between March 22 and November 27 and still

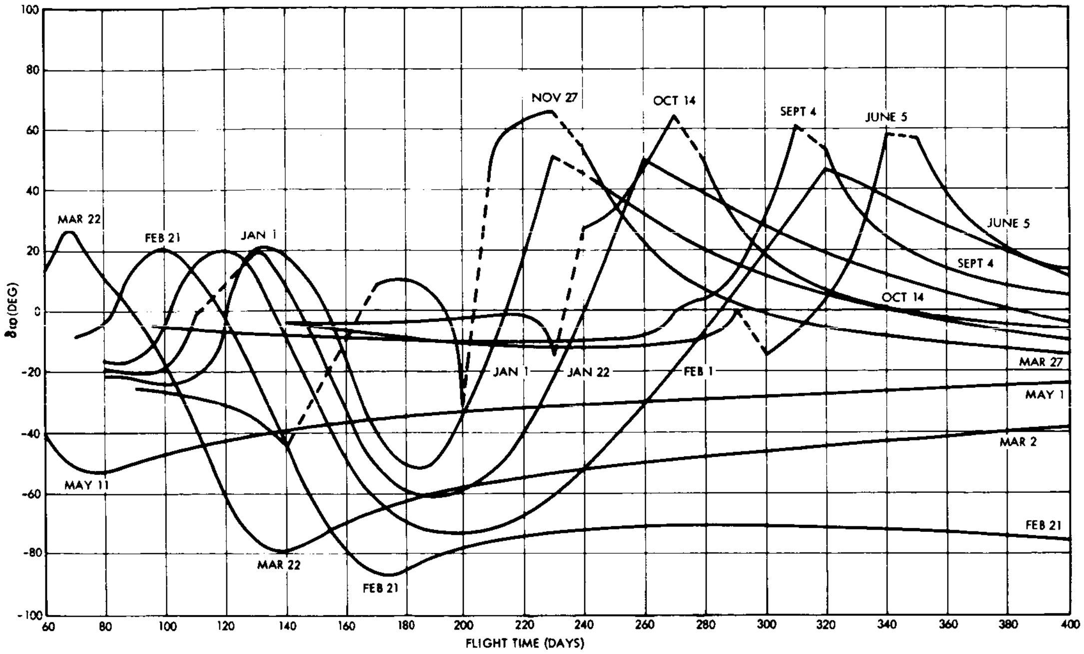


Figure 4-5. Declination of Velocity Vector on a Given Launch Date as a Function of Flight Time

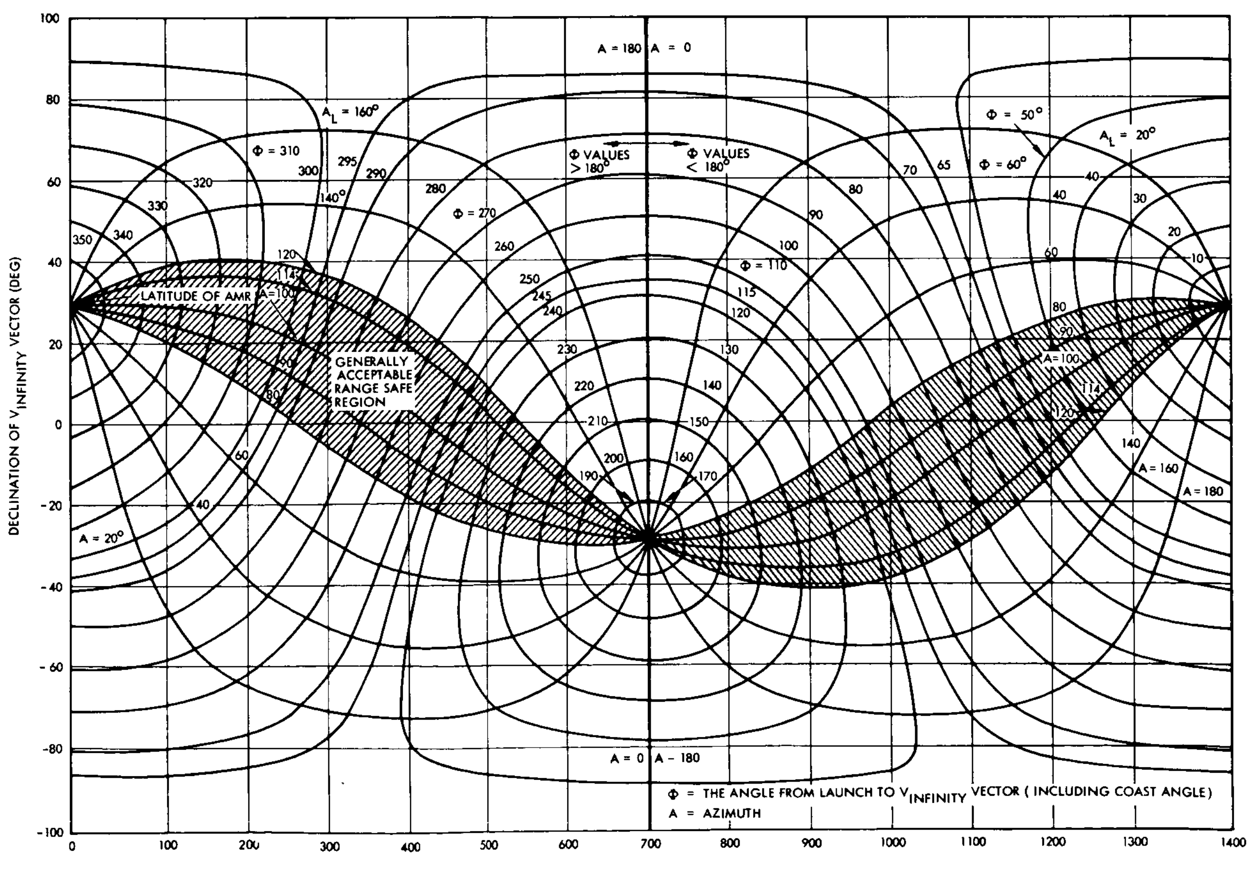


Figure 4-6. Contours of Azimuth and In-Plane Angle for Declination of $V_{infinity}$ Vector and Launch Window

keep our flight time under 200 days. For example, between February 21 and March 22 there are many declinations between +20 degrees and -40 degrees with flight times of between 80 to 140 days. The daily launch window for such trajectories will be completely satisfactory.

There is still another important characteristic missing — the sensitivity of the particular trajectory selected to errors at injection. At booster burnout, large guidance errors still remain, and these must be corrected during the course of the transit trajectory to insure impact. We cannot carry out a detailed error analysis over all comets and energies. However, we can conveniently introduce a "guidance figure of merit," simple enough to be included as a part of the basic calculations for all missions, yet sufficiently meaningful to allow us to draw useful conclusions about the guidance problems, and more particularly the midcourse correction requirements. These are based on computations of miss coefficients at the comet resulting from injection errors. For each of these trajectories computed, a set of injection errors were assumed. These were: a 2 n mi error in injection altitude; two-tenths of a degree error in both right ascension and declination; one-third of a degree error in azimuth and in flight path angle; and a 10 fps error in the burnout velocity. The errors have been combined into a single figure of merit, and formed the rss of the individual misses.

Figure 4-7 shows the miss distance which can be expected at the comet with these errors at injection. Since midcourse corrections will reduce these misses by two orders of magnitude, the principal purpose of showing these curves is to indicate the launch conditions which will minimize the expected miss distance and hence, minimize the propulsion required to make the midcourse correction. However, as a general rule, the miss coefficients are inversely related to the miss distance. Thus, if the miss is large, a small correction can readily compensate for the error, and conversely, if the miss is small it may take a large correction to eliminate such an error. Experience also indicates that with highly inclined orbits, the miss sensitivities are substantially larger than might be intuitively expected. Therefore, when a particular comet is highly inclined, it should be expected that the out-of-plane effect will result in

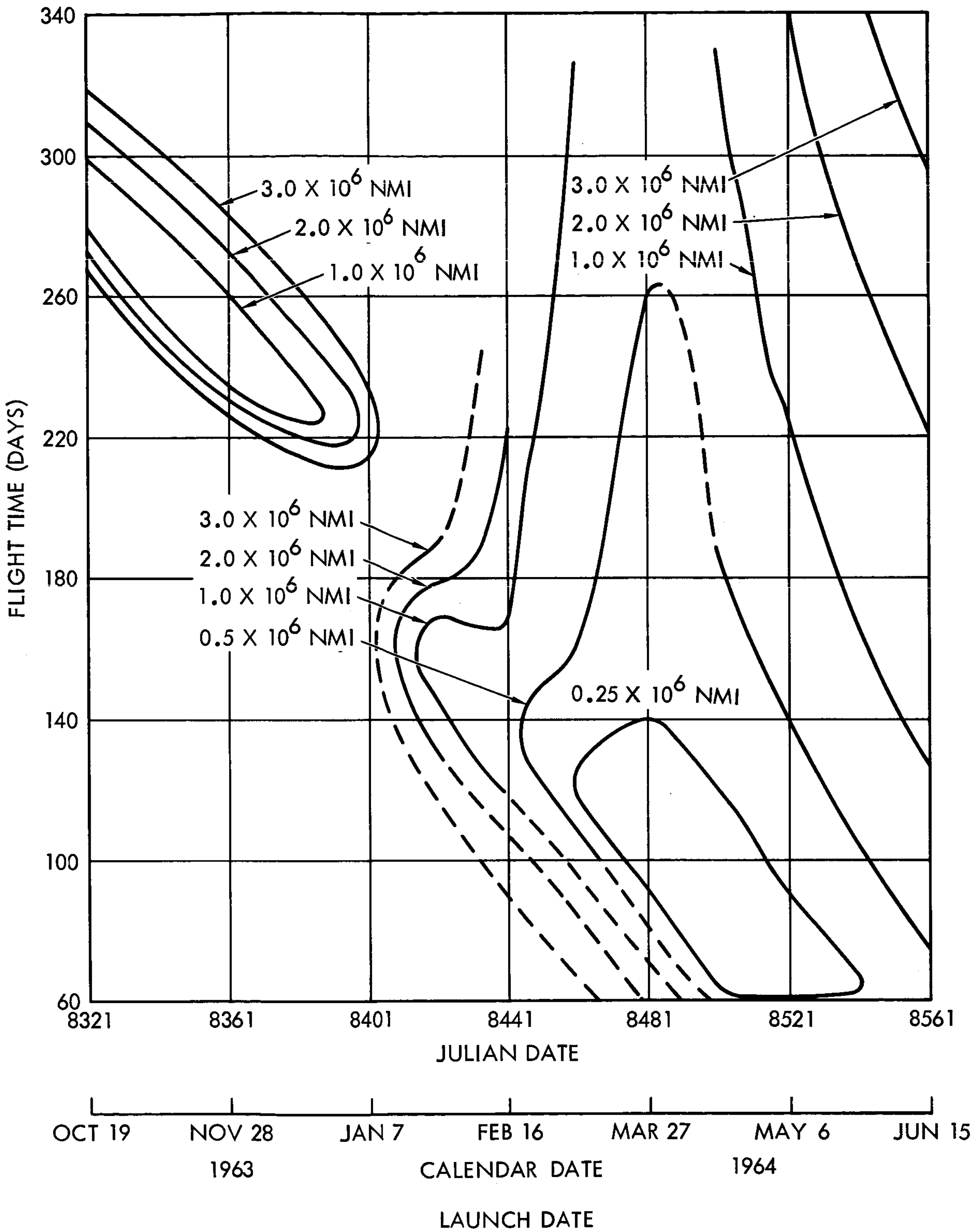


Figure 4-7. Miss Distance as a Function of Flight Time and Launch Date, Encke, 1964

large sensitivities. Nevertheless, these curves do indicate regions which should be avoided and indicate the magnitude of the corrections required and call attention to high risk trajectories.

Thus far we have considered the trajectory conditions only in terms of what happens at earth or at intercept, but these transfer trajectories to the comet can also be usefully examined in the sun's frame of reference. On the transfer trajectories to Encke during the 1964 launch interval, we noticed that there were a wide range of flight times available for a given injection velocity, especially for the Class I trajectories. The same launch interval in the sun's frame of reference for the velocity of the spacecraft with respect to the sun, given in Figure 4-8, shows that the long transit trajectories are associated with the largest velocity in the sun's frame of reference, as would be expected, and the shortest flight times have the lowest sun frame velocities.

Velocities below 97,000 fps mean, of course, that the transfer orbit has less energy than the earth in its orbit, and such trajectories will either be highly eccentric or smaller than the earth's orbit. If we look at Figure 4-9, eccentricity of the transfer trajectories, we see that this is the case. Obviously, the eccentricity of the orbit depends upon not only the injection energy but also the angle of which the spacecraft goes into orbit of the sun. This angle is made up of two components: Beta is the angle of the $V_{infinity}$ measured from a radial line from the sun through the earth at launch. Beta is 90 degrees when the $V_{infinity}$ vector is essentially tangential to the earth's velocity, zero degrees when $V_{infinity}$ lies along a radial line, and 180 degrees directly in toward the sun. The other component of the angle is the inclination of the spacecraft trajectory with respect to the ecliptic — when inclination is positive the trajectory is above the ecliptic and, when negative, below the ecliptic. Figures 4-10 and 4-11, of beta and inclination for launches to the comet Encke in 1964, show the features which we expect. For example, for launches from March through July, the inclination gets gradually smaller (from -15 to -2.5 degrees) with flight time. Since, at this time, both the spacecraft and the comet are going out away from the sun, if the flight time is short, the spacecraft trajectory must be at least as inclined as the comet orbit (which is inclined by about 12 degrees) to intercept early and must be negative

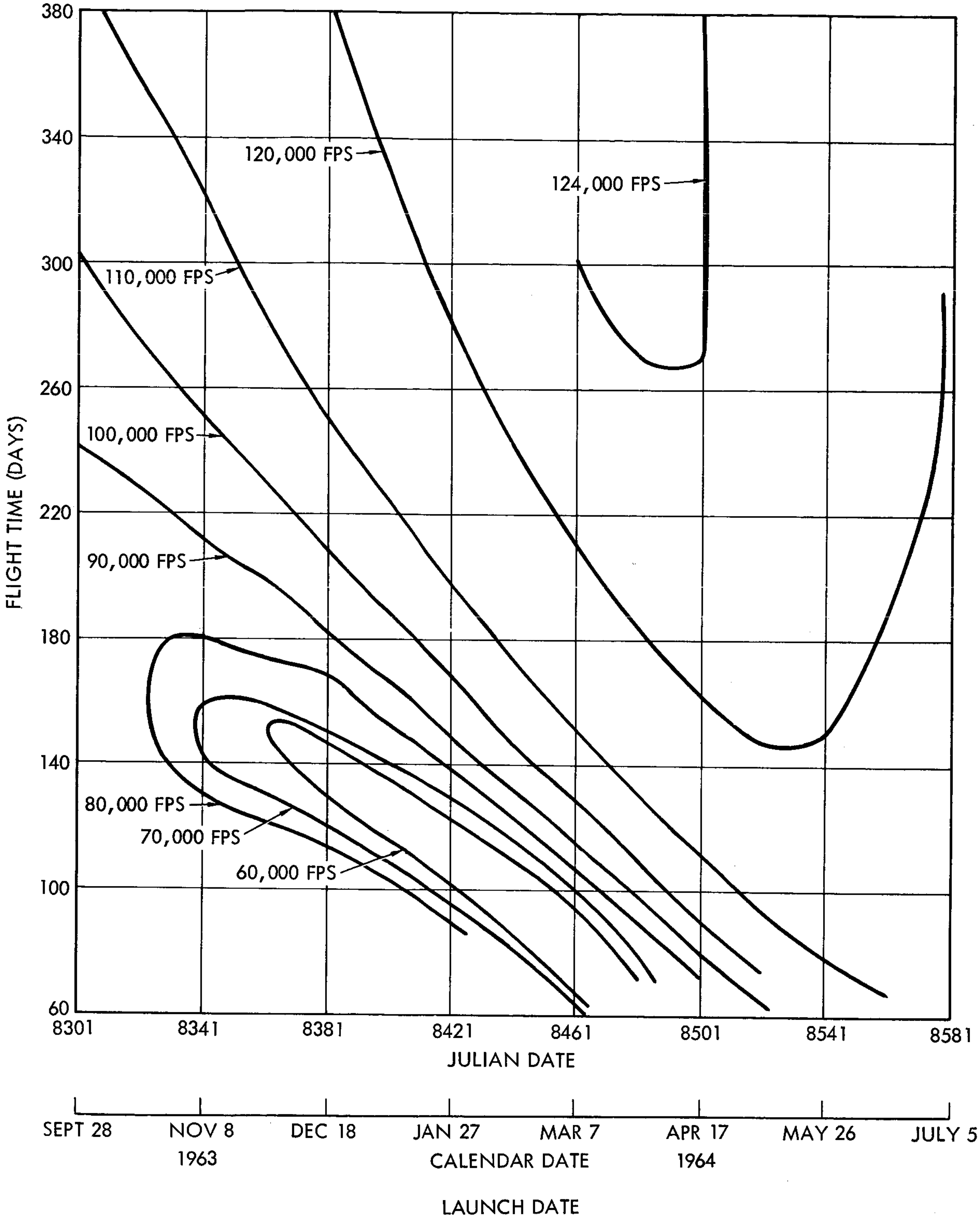


Figure 4-8. Heliocentric Velocity of Spacecraft as a Function of Flight Time and Launch Date, Encke, 1964

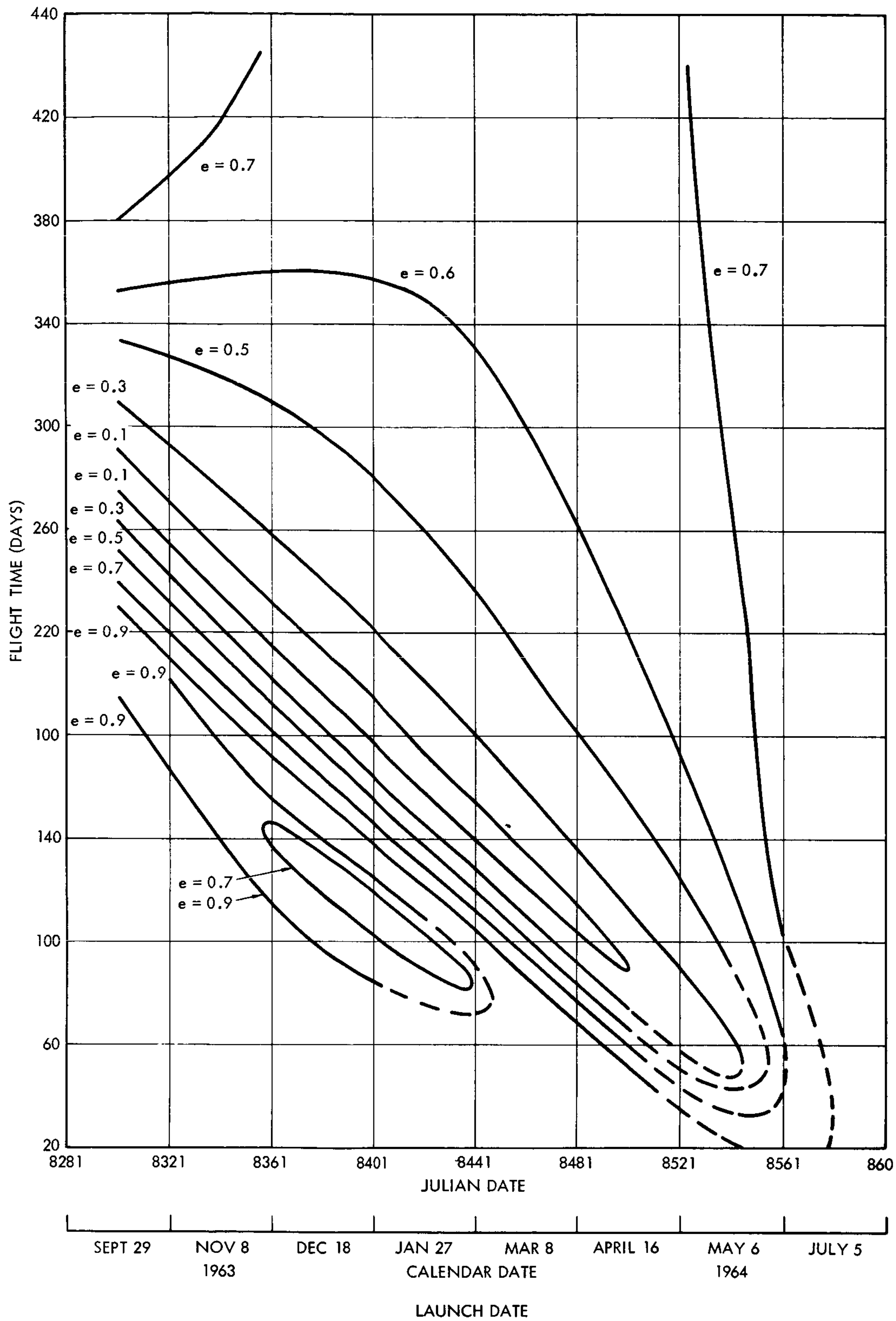


Figure 4-9. Eccentricity of Transfer Trajectory as a Function of Flight Time and Launch Date, Encke, 1964

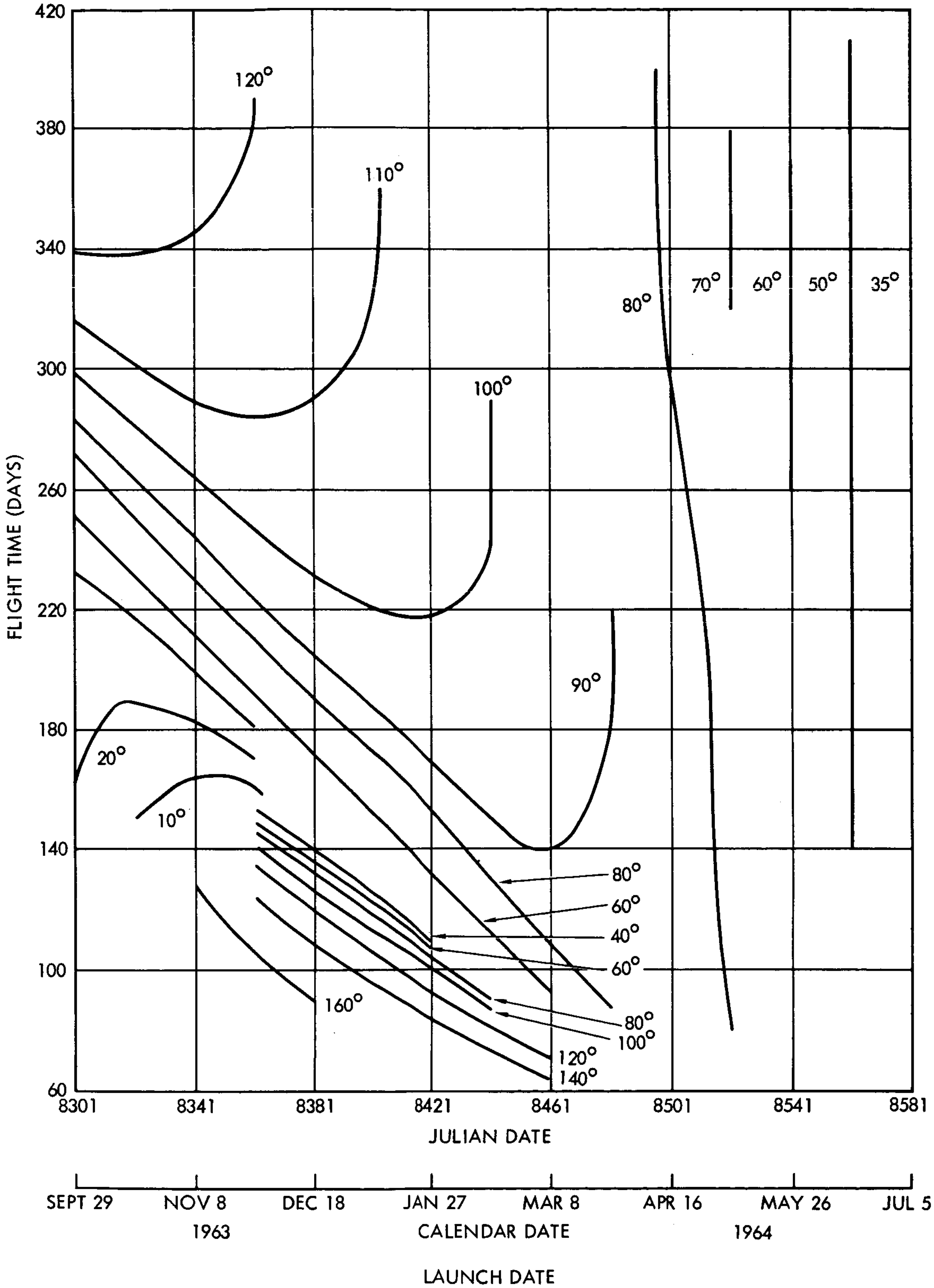


Figure 4-10. Heliocentric Launch Angle, β, of the Transfer Trajectory as a Function of Flight Time and Launch Date, Encke, 1964

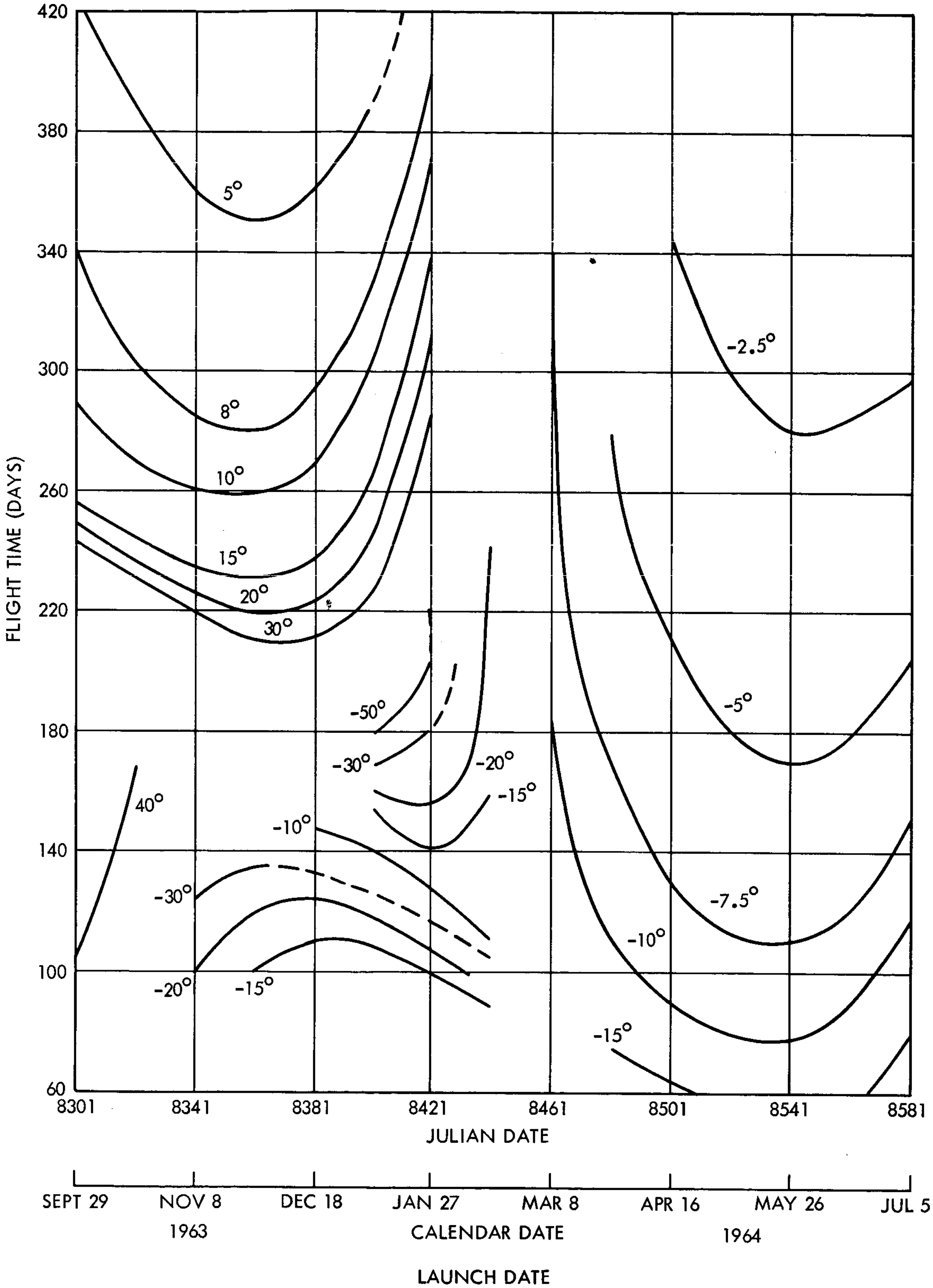


Figure 4-11. Sun Frame Inclination of the Transfer Trajectory as a Function of Flight Time and Launch Date, Encke, 1964

since the comet has just passed through its descending node. However, as the flight times get longer, the inclination will become smaller and smaller since the intercept point is farther and farther along the comet orbit. The same launch region for beta shows that for a given launch date, beta is essentially vertical, which means that flight time is changed only by changing our inclination. This property is shown even more clearly in Figure 4-12 where the contours are of fixed flight times. Here we see that flight times from 100 to 400 days can be achieved on the same day with the same beta from 35 to 85 degrees, but higher betas are associated only with longer flight times.

Figure 4-13, which shows contours of heliocentric in-plane angle from earth at launch to intercept, indicates not only the correlation between flight time, launch time and distance about the sun, but also shows that the angle traversed is relatively insensitive near the arrival time corresponding to the low energy trajectories studied. What is implied by the fact that many transfer angles can be used for the same flight time, especially for early launches, is that the spacecraft can leave the earth in many directions and still intercept the comet. Later, during the launch window, the spacecraft can leave the earth in essentially only one direction.

## 2. Guidance

The guidance requirements for a comet mission were analyzed using the following guidance procedures: (Comet Encke was used for analysis.)

a) Use the optical data from an earlier apparition of a comet to determine its orbit and predict the intercept orbit

b) Begin optical tracking at the first appearance of the comet during its intercept apparition

c) Launch the spacecraft on the basis of both sources of data

d) Track the spacecraft

e) Continue optical tracking of the comet to improve the orbit estimate

f) Use midcourse corrections to reduce the errors caused by injection inaccuracy and error in the earlier comet orbit estimate.

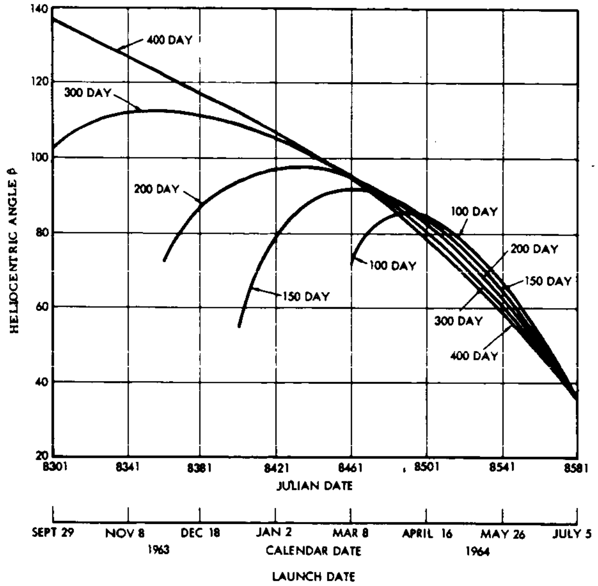


Figure 4-12. Contours of Constant Flight Time Encke, 1964

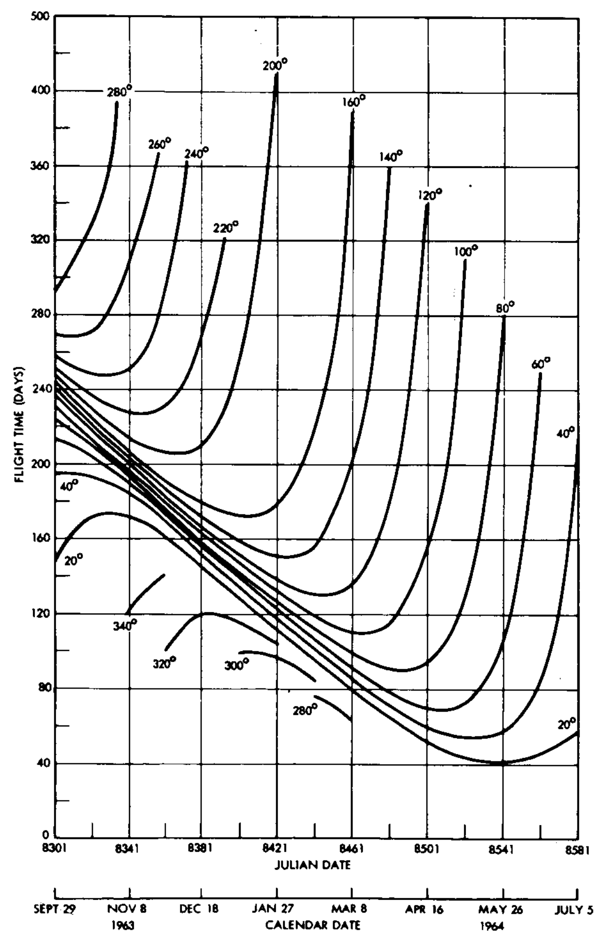


Figure 4-13. Contours of Heliocentric In-Plane Angle, θ, Encke, 1964

The results of this analysis shows that the comet orbit optical tracking error, assumed to be 2.5 seconds of arc for each observation, is currently the largest contributor to both midcourse fuel requirements and final miss. The probability of having the spacecraft pass within 10,000 km of the nucleus of the comet with this error but after 8 months of observation is about 0.5. This probability could be improved to about 0.99 if the optical tracking error were reduced by a factor of 3. An improvement of this magnitude is possible if the dim stars which are used as references for the comet observations are themselves located more precisely from the basic stars. Although this clearly can be done, it has not been since there has been no need for this degree of accuracy previously.

Miss Coordinate System. The coordinate system used is discussing the miss caused by the various errors is the "impact parameter" system. The three axes are known as the $b_1$, $b_2$, $b_3$ axes, and are defined in terms of Voo (the velocity vector of the spacecraft relative to the target) and the equatorial plane. The $b_1$ axis is along the negative of the $V_{infinity}$, while the $b_2$ and $b_3$ axes are in a plane perpendicular to the $V_{infinity}$ vector (the impact-parameter plane). The $b_2$ axis is along the intersection of the impact-parameter plane and the equatorial plane, and the $b_3$ axis is roughly north. The system is right-handed. The $b_2$ and $b_3$ values indicate the closest approach distance while the $b_1$ value indicates the arrival time error when it is divided by $V_{infinity}$.

Prior Orbit Optical Tracking Error. The error resulting from tracking Encke for nine months in 1960-61 was determined for data rate of 1 observation per week with a $1\sigma$ angle error of 2.5 seconds. When the position at the time of intercept is predicted from this data the $1\sigma$ values of the errors in $b_1$, $b_2$, and $b_3$ are the following:

$$\sigma_1 = 129.4 \text{ Mm}$$
$$\sigma_2 = 129.3 \text{ Mm}$$
$$\sigma_3 = 1.677 \text{ Mm}$$

where 1 Mm = $10^3$ km. The arrival time $1\sigma$ error is 67.3 minutes.

Because the 1964 position was obtained by predicting about three years ahead, the errors tend to be highly correlated. The correlation coefficients are:

$$\rho_{12} = 1.000$$

$$\rho_{23} = 0.979$$

$$\rho_{31} = 0.979$$

A higher data rate does not yield significantly better accuracy because the position of the comet is measured relative to a dim star background (which is itself the source of most of the uncertainty), and observations taken closer than one week apart would be so highly correlated that no new information would be gained.

<u>1964 Optical Tracking Error.</u> Eight months of tracking the 1964 passage were simulated with the following results:

| | |
|---|---|
| $\sigma_1 = 6.59$ Mm | $\rho_{12} = -0.842$ |
| $\sigma_2 = 9.90$ Mm | $\rho_{23} = -0.0611$ |
| $\sigma_3 = 3.42$ Mm | $\rho_{31} = 0.0795$ |

Time of arrival $1\sigma$ error = 3.46 minutes. These errors could be reduced by a factor of 3 if the locations of the dim stars in the background were established more accurately.

<u>Injection Error.</u> The miss caused by a representative set of errors in injecting the spacecraft into its transfer orbit was evaluated with the following results:

| | |
|---|---|
| $\sigma_1 = 175.2$ Mm | $\rho_{12} = -0.906$ |
| $\sigma_2 = 155.3$ Mm | $\rho_{23} = -0.567$ |
| $\sigma_3 = 146.0$ Mm | $\rho_{31} = 0.573$ |

Time of arrival $1\sigma$ error = 92.2 minutes.

<u>Spacecraft Tracking Error.</u> For this mission the error involved in tracking the spacecraft is negligible compared to the error in tracking the comet. The $1\sigma$ values can be less than 1 Mm with reasonable data rates.

Midcourse Velocity Execution Errors. An overall midcourse correction accuracy of about 1% $3\sigma$ (1% in velocity magnitude and $0.6^{\circ}$ in orientation) introduces essentially no error compared to the optical tracking error. Therefore, one correction with a 1% system could be made, or two corrections with a 10% system could be used (10% in velocity magnitude and $6^{\circ}$ in orientation).

Midcourse Velocity Requirements. The midcourse velocity sensitivities are displayed graphically in Figures 4-14, 4-15, and 4-16. These sensitivities were used to calculate the velocities required (in a statistical sense) to correct the uncorrected miss with a high (>0.99) probability of having sufficient fuel. One firing was assumed at various times along the transfer orbit. The velocity required to correct the three-dimensional miss and the velocity required to correct only the $b_2$ and $b_3$ components (the "critical-plane" correction) were both calculated and are plotted as functions of time in Figure 4-17. For these corrections it was assumed that the spacecraft could be oriented to the desired attitude before the firing.

Error Ellipses. Figure 4-18 shows the $1\sigma$ error ellipses for both periods of optical tracking and for the injection errors. Also shown is a 10 Mm circle which can be considered to be the target area. In this figure only the center of the 1960-61 tracking ellipse can be seen since it is quite large compared to the target area.

The significant comparison to be made is between the 1964 optical tracking ellipses and the target circle. The 1964 optical tracking ellipse essentially describes the final miss after the midcourse corrections. Note that this ellipse is entirely within the target circle. There is, therefore, greater than $1\sigma$ probability (46.5%) of passing through the target area. If the tracking error were reduced by a factor of 3, the probability of passing through the target area would be about at the $3\sigma$ value (99.5%). The over-all improvement would not be quite a factor of 3 since the spacecraft tracking and velocity execution errors would then start to become important, but the probability could easily be improved to 90%.

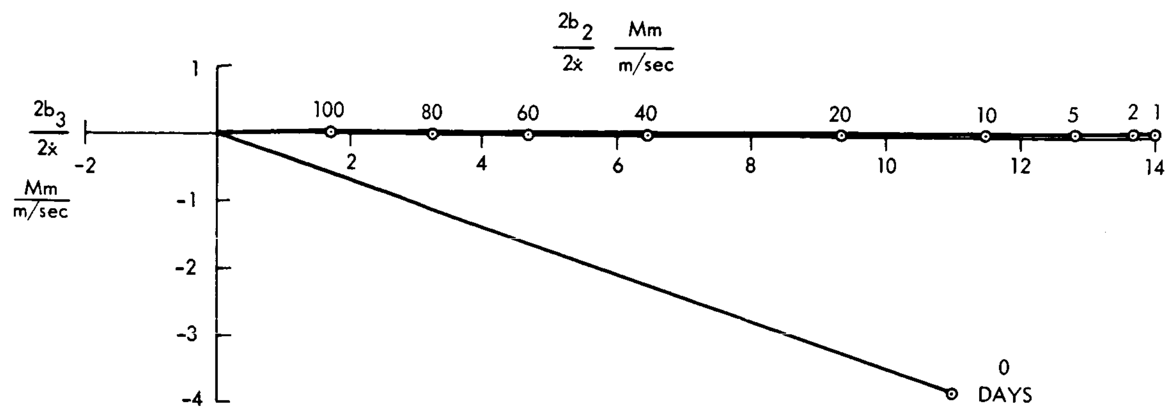


Figure 4-14. Miss Sensitivities in X Direction (Equatorial) as a Function of Day of Correction

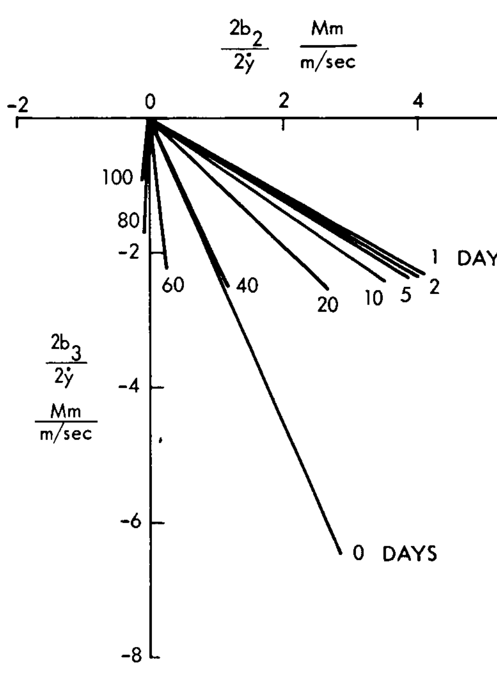


Figure 4-15. Miss Sensitivities in Y Direction (Equatorial) as a Function of Day of Correction

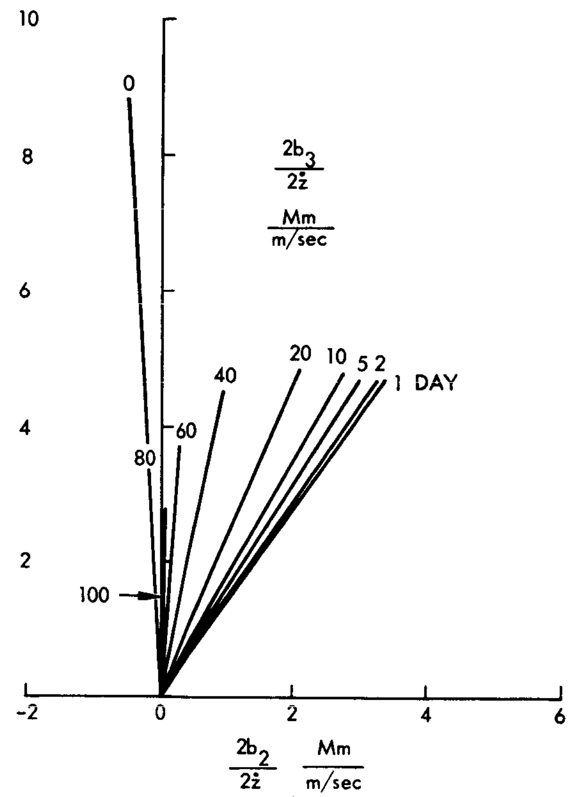


Figure 4-16. Miss Sensitivities in Z Direction (Equatorial) as a Function of Day of Correction

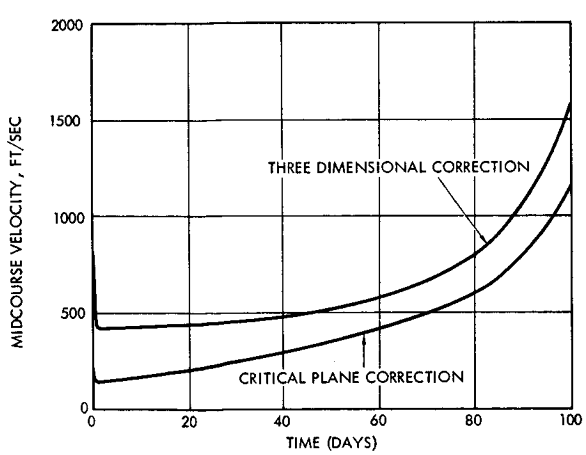


Figure 4-17. Midcourse Velocity Requirement as a Function of Time for Correcting Injection Errors Plus Comet Ephemeris Errors

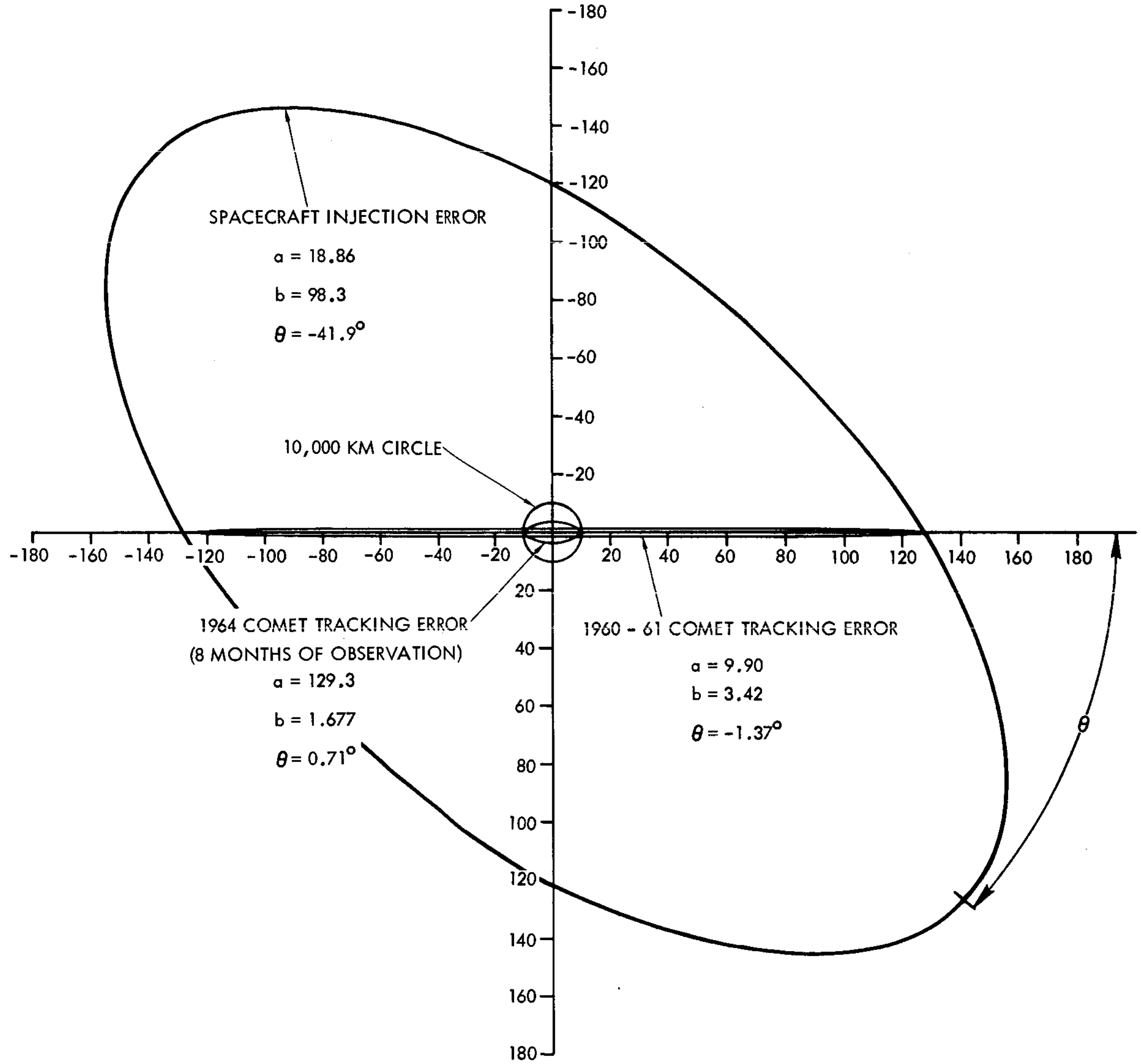


Figure 4-18. Error Ellipses for a March 1964 Launch to Encke

### 3. Spacecraft and Subsystem Requirements

Flight times between 100 and 300 days are required for a wide-range comet mission, and transmission distances between 20 and 200 million nautical miles are also required. In addition, as described in Chapter 3, experiments weighing a minimum of about 50 pounds and up to 100 pounds will be required. Power requirements will vary primarily as a function of transmission distances, but a minimum of 100 watts is desirable. In addition, a propulsion system is required to perform midcourse and terminal maneuvers.

The comet spacecraft must be able to assure that it hits the comet and adjusts its velocity in the vicinity of the comet; it must have a communications system, a data handling system, a propulsion system, a thermal control system, a power supply system, and some type of attitude control system, as well as carrying an experiment package. The key factors in the over-all spacecraft design are that it must be extremely simple, and reliable, but it must also have a reasonable cost with high probability of success. An appreciable item of cost and reliability is the attitude control system. A fully attitude controlled system determines the maximum life-time of the spacecraft because it requires a supply of cold gas which must be finite. Since comet missions encompass a wide range of flight times, transmission distances, and thermal environments, we have considered the alternative of using a spin-stabilized spacecraft since such stabilization is not only permanent, but costs less. During the last year, STL has been studying a spin-stabilized spacecraft for NASA's Ames Research Center, which is specifically designed to explore interplanetary space. Much of the work done for that spacecraft study applies equally well to this comet mission and is used here. Communication ranges considered in that study were between 100 and 200 million miles and the spacecraft lifetime was of the order of six months or 180 days. Although the success of the Mariner II mission to Venus indicates that the fully attitude controlled system can be expected to operate effectively over life times of up to 6 months, the reliability of such a system must, of necessity, be lower and the cost somewhat higher. Therefore, we have decided to consider the simplest type of probe that can carry out the comet intercept mission.

Typically, such a spacecraft requires approximately 50 pounds for communications, 100 pounds for power supply, 150 pounds for propulsion, 20 pounds for temperature control and with a 50 pound experiment, about 70 pounds of structure, giving a total of about 450 pounds. Since such a spacecraft weight is about the same as the Mariner II, but without any allowance for attitude control, we will find that a spin-stabilized system should save us at least 30 to 40 pounds and substantially increase system reliability. A specific spacecraft, suitable for this mission, is described in some detail in Section V.

4. Booster Capabilities

The principal consideration in the selection of a booster for a comet mission is that it satisfies the velocity requirement with a suitable payload. Injection velocities between 38,000 and 50,000 fps will carry us to most comets, and as we have shown above, a spacecraft weighing in the order of 400 to 500 pounds can quite easily carry out the full comet mission*. Of course, our primary interest is with injection velocities around 40,000 fps since most available low-cost boosters do not have a payload capability much in excess of 500 pounds at velocities of 42,000 fps. Since this energy requirement is not much greater than those to Venus or Mars, which require between 37,000 to 40,000 fps, boosters do exist, as evidenced by the Mariner II mission, which can perform this mission. Mariner II spacecraft weighed about 450 pounds and was boosted by the Atlas-Agena booster.

If we assume that the mission is to be carried out within the next few years, we cannot include boosters such as those for the Saturn vehicle, which are not only very expensive but reserved for the U. S. manned lunar program. Other vehicles which are in the state of development, such as various combinations using the Titan II or the LOX Centaur upper stage are not yet available for space missions but will probably become available in two or three years. Nevertheless, these booster vehicles are in large part spoken for and are probably more expensive and more complex than is necessary for the relatively simple mission contemplated here. Therefore, there are two readily available vehicles. One, the Thor-Delta vehicle, has too small a payload

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*Booster payload capabilities were calculated for injection at 100 nmi and the injection velocity requirements for each comet were calculated for an injection at 177 nmi; consequently, some additional energy will be required of the booster (350 fps).

capability to be suitable for this mission since it can carry only about 100 pounds to escape velocity. However, as we know, the Atlas-Agena vehicle, used on the Ranger and Mariner missions, has performed quite reliably and will doubtlessly improve in the future. However, as a two-stage vehicle it probably does not allow an adequate margin for launch on such a mission; hence it will require the addition of a solid propellant third-stage such as has been used on the Thor-Delta and has been used on the Atlas-Able 5 lunar missions. We can reasonably assume that with a third-stage such as the ABL 258, about 500 pounds of payload can be injected to 41,000 fps. Attachment No. 1 (Confidential) contains graphs showing the specific performance of various vehicle combinations discussed above. With the Atlas-Agena vehicle, the mission not only has a proven booster, but one which is currently in production, relatively easy to obtain, and considerably less expensive than the larger, newer vehicles. Moreover, launch systems for this vehicle are already available at both the Atlantic and Pacific Missile Range which considerably simplifies the launch logistics problem.

5. Launch Schedule

Launching a spacecraft is a complex task which requires many months of planning for the specific mission and many years of planning to integrate a specific mission into the overall U. S. space program. In most cases, launch stands have been allocated 2 years in advance and every space mission must consider its impact upon all other space missions. For this reason it is essentially impossible at this time in the U. S. space program to plan a launch to a new comet since such a mission would require that a specific launch stand be made available as soon as a new comet is discovered. This, in turn, would probably require rescheduling of a part of the U. S. space program. Moreover, since time is required to determine the orbit of the comet accurately, the planning for the mission could not be completed until some months after the initial observation. Finally, the behavior of comets is still very unpredictable and in some cases the comets have divided or behaved in an otherwise unusual fashion which would make the targeting and the intercept problem greater. Therefore, we should choose to intercept comets whose behavior in the past has been predicted, if possible, and whose orbit is known accurately.

Let us examine how much time is required to launch a spacecraft to a comet. If we sight a comet, such as Encke, at least 2 or 3 months of careful astronomical tracking will be required to make a good initial orbit determination. Then, at least 2 weeks of trajectory computation for the boost vehicle and the free flight trajectory must be added. During these 2-1/2 months, the launch vehicle can be shipped to the Cape and checked out, the launch pad prepared, and the spacecraft delivered. In addition, the complete upper stage and payload can be checked out at Florida. However, the guidance constants cannot be established until after the booster and free flight trajectories have been determined and these will require an additional 2 weeks and subsequent to this, another week for final checkout and launch will be required.

This means that a minimum of almost 3-1/2 months are required from the initial sighting of the comet. Figure 4-19 shows the launch site time requirements. However, the actual launch window selected in advance may not occur until 4 or 5 months after the initial sighting of the comet (this appears to be the case for the comet Encke in 1964 as indicated earlier). Such a situation is desirable since it appears that at least 8 months of optical tracking is required before intercept. However, for many other comets, as we have indicated and even for comet Encke, on some years it might be difficult to acquire the comet sufficiently early to guarantee an appropriate time for launch preparations. All comet missions must therefore be planned with all of these practical matters in the foreground.

In addition, the planning must also consider the problems of the boost trajectory. These include declination, range safety considerations, payload capability, and aerodynamic considerations. Since we must, in general, launch either from Cape Canaveral or the Pacific Missile Range, we have a limited number of range safe azimuths which we can use and these tend to limit the actual intercept trajectories we can fly, although coasting trajectories considerably alleviate this problem. Nevertheless, the boosters to be used have a limited payload capability and cannot make turning maneuvers to get them on the correct path easily since such a turn costs a great deal of payload. Moreover, aerodynamic heading, the effects of winds, and other aerodynamic considerations also tend to constrain the boost trajectory to a fairly narrow band of alternatives.

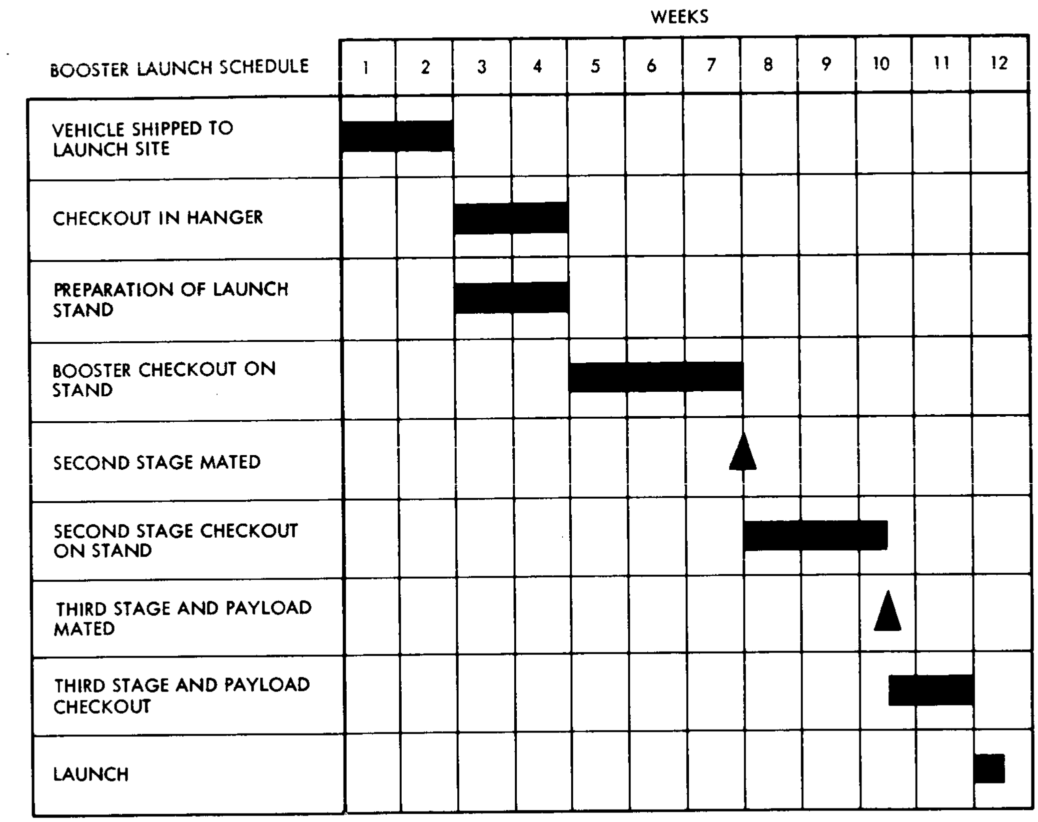



Figure 4-19. Typical Launch Site Schedule

Although launch considerations are quite important and at this stage in space exploration tend to eliminate new comets from our planning, there appears to be no serious difficulty in planning an effective comet intercept mission.

6. Reliability

The basic problem for any spacecraft mission is essentially one of cost versus probability of success. The key element in a comet mission is that opportunities to launch to a specific comet with a high probability of success are very infrequent and the duration of the launch interval or window is, at most, a month or two. Under this condition, we cannot expect more than two launches to be made within the launch window. Experience indicates that for a single shot mission to be successful, the system reliability must be extremely high, requiring simplicity of design, very large design margins, and almost complete equipment redundancy.

To give a very high reliability of mission success, a minimum of two launches is necessary and a large payload margin desirable. In large measure, the reliability of the spacecraft depends upon the total number of parts carried and upon our knowledge of the operational effectiveness of these parts in the space environment. Another key element of the reliability complete system is the reliability of the booster vehicle. The booster suggested earlier in the report, that is, the Atlas Agena, has at present a fairly high reliability and it is expected that this reliability will continue to increase, although a 6 month or 180-day duration in the space environment requires almost complete redundancy throughout the spacecraft. It is also imperative that only proven components and subsystems be used, a thorough test and evaluation program be applied to all the equipment, and complexity be minimized in all areas. Special manufacturing and quality assurance procedures should be followed and ample time be allowed for a special reliability demonstration program.

Moreover, the program should be planned in such a way as to ensure that no unusual development and test differences are required and to ensure that no advances of the state of the art are required.

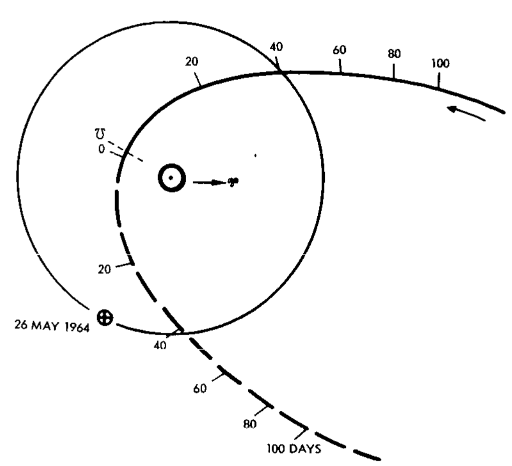
Appropriate reliability figures are: a 0.7 for the booster and a 0.8 probability of surviving six months for the spacecraft and subsystems, exclusive of experiments. Such spacecraft reliability can be achieved without great difficulty and a reliability of 0.7 for the type of booster proposed should be achievable in the near future.

## B. MISSION REQUIREMENTS FOR SPECIFIC COMETS

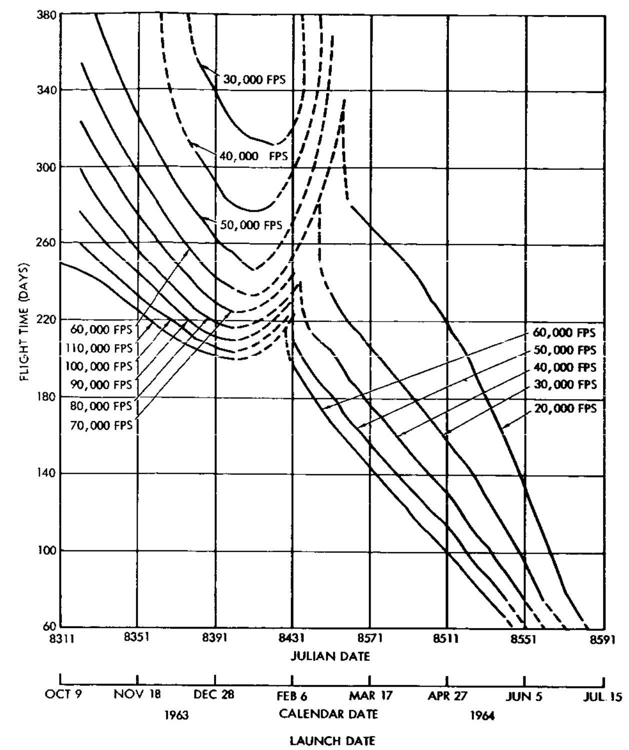
On the following pages are presented the injection velocity requirements and transmission distance to the probe at intercept; the closing velocities; and the miss at intercept for each of the comets studied in detail.

# ENCKE

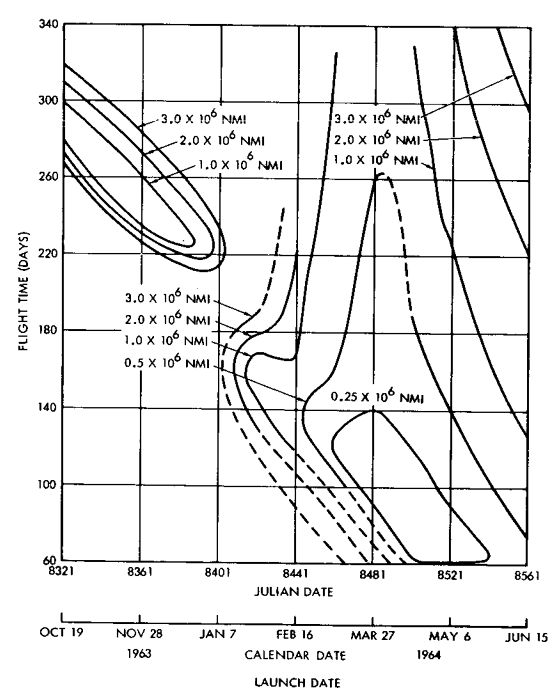
Encke is an excellent target in 1964. In its next appearances—these velocity requirements are shown on the next page—it is not as well located and the minimum velocity, requirements, even in 1974, are 42,000 fps which are associated with flight times in excess of 200 days. In 1964, however, with 42,000 fps, a flight time of 100 days is possible and there is a launch window of over 3 months. The closing velocities in 1964 can vary between 20,000 to 60,000 fps, depending largely on the precise launch date and somewhat on the injection velocity. The miss at the comet, as shown, can be extremely small, in the order of 250,000 miles, and a sensitivity to the out-of-plane component will not be excessive.




Path of the Comet Rotated Into the Ecliptic



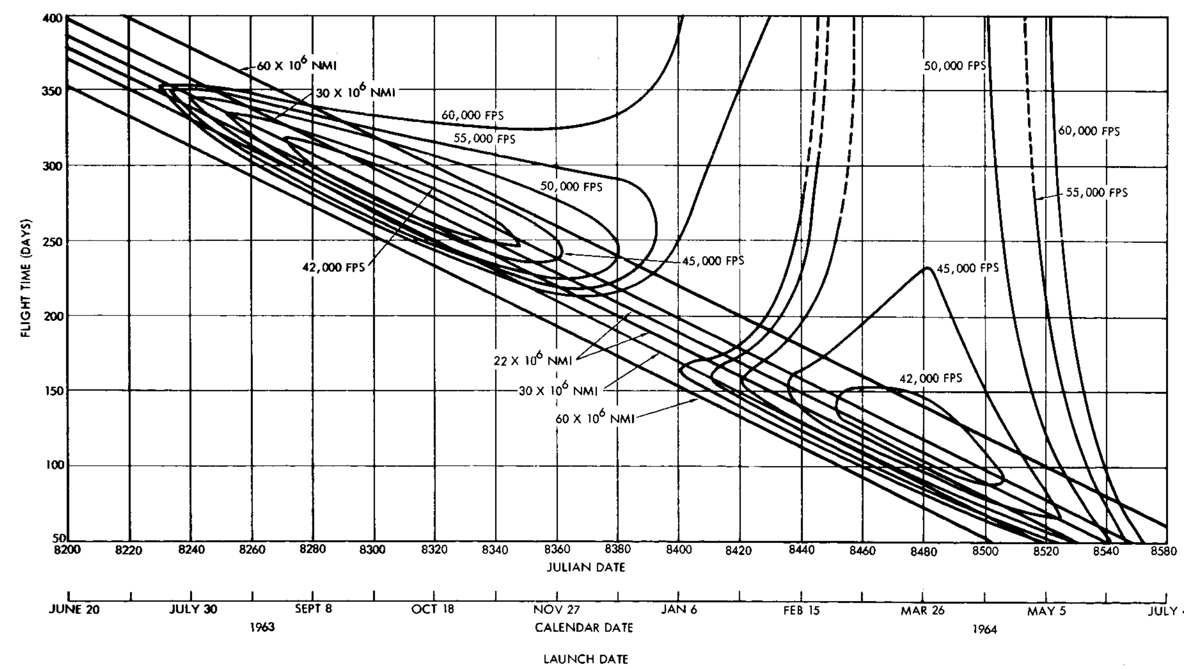

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

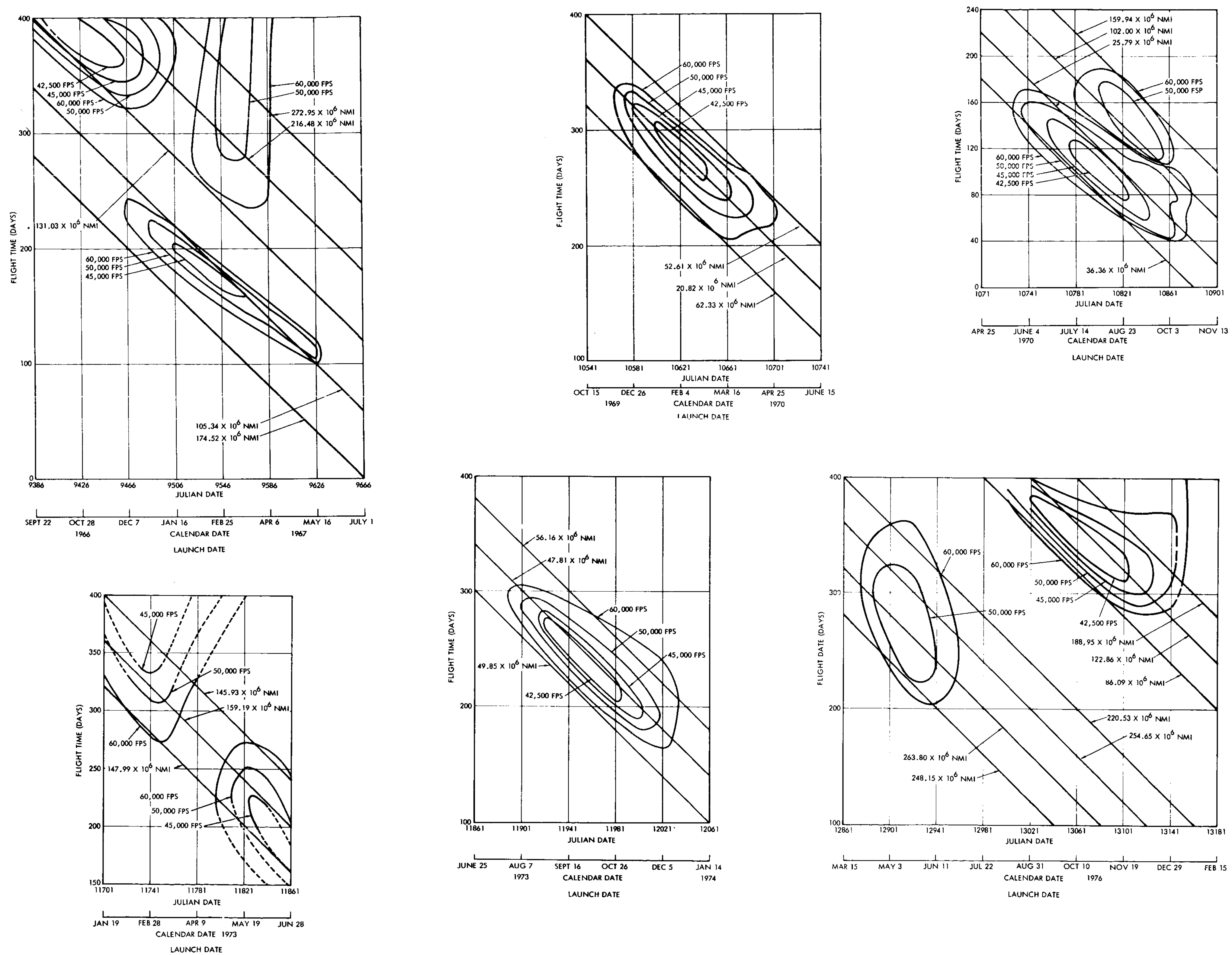
Legend:

q = 0.339 AU
i = 12.4°
e = 0.847



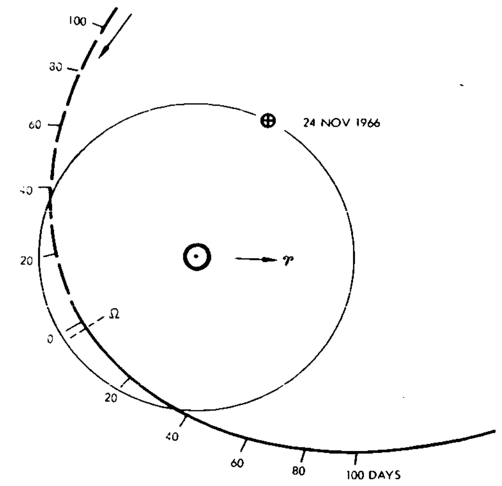

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

# INJECTION VELOCITY REQUIREMENTS FOR COMET ENCKE, 1967 TO 1977

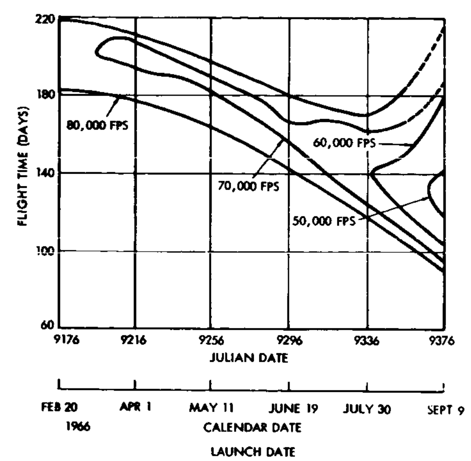


## GRIGG-SKJELLERUP

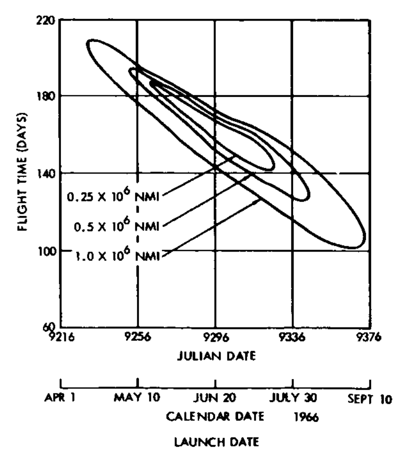
Grigg-Skjellerup presents a relatively poor target in 1966, 1971, and 1976, and at some later date, launch conditions will be much better. However, the flight time for reasonable velocities is between 150 to 200 days. With an injection velocity of 45,000 fps, a launch window of 3 months is available and the transmission distance is near minimum, about 45 million miles. The closing velocities will be at the minimum of about 70,000 fps and could quite easily be larger. The anticipated miss distance in the region of interest can be as small as 250,000 miles. Since Grigg-Skjellerup is inclined by 17.6 degrees, the miss sensitivities will be substantial.




Path of the Comet Rotated Into the Ecliptic



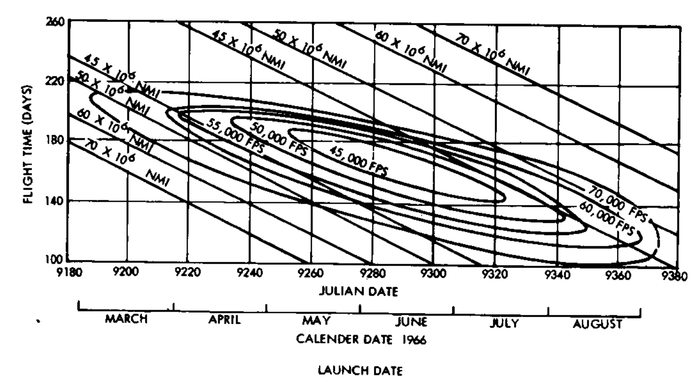

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

q = 0.855 AU
i = 17.6°
e = 0.704

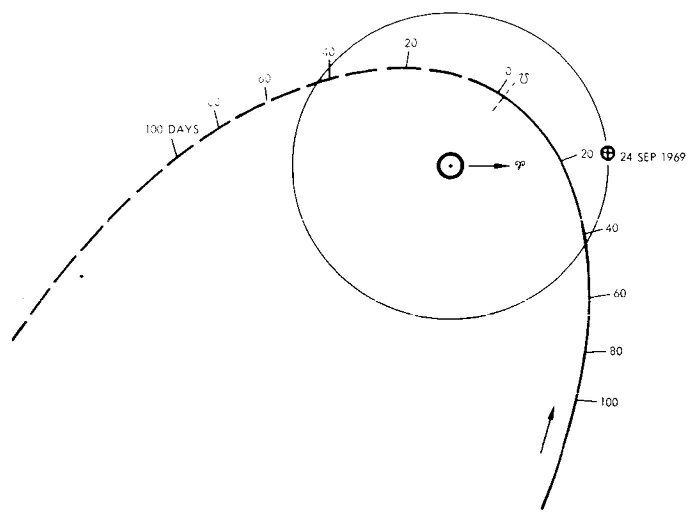



Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

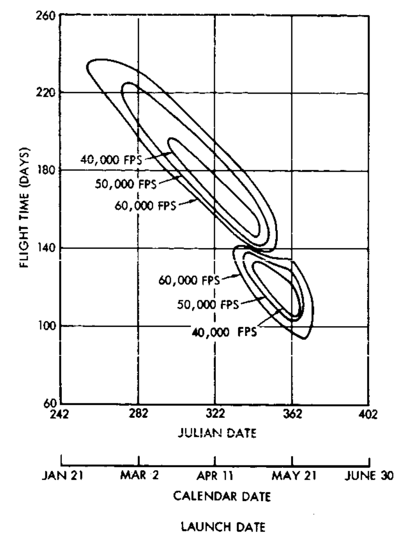
## HONDA-MRKOS-PAJDUSAKOVA

Honda-Mrkos-Padjusakova presents a fair target in 1969, an excellent target in 1974, and a rather poor target in 1964. As can be seen on the velocity contours for a 1969 launch, velocities of 42,500 fps can be used during 3 different launch intervals,* one with a flight time as short as 100 days and perhaps one-half month of launch window. The transmission distance can be as low as about 30 million miles. The closing velocities indicate that we can expect to be between 40,000 to 62,000 fps. The miss distance is in the order of 1 to 2 million miles and will not present a substantial problem, particularly since the inclination of the comet is 13.2 degrees.

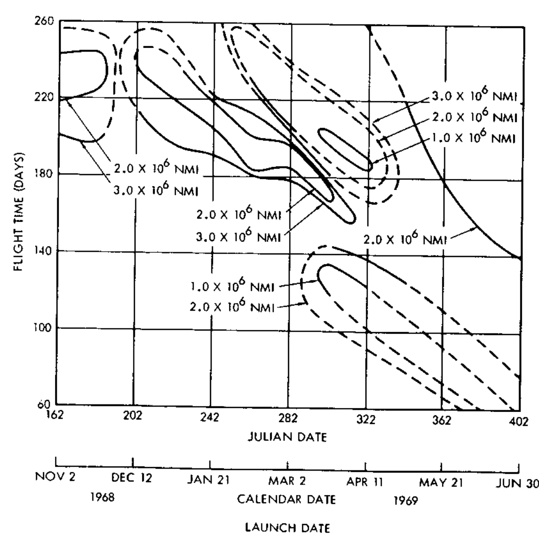
*Note: The reason that there are 3 contours shown on this trajectory is not clear to us at this time, but similar events events have been observed on some interplanetary trajectories.




Path of the Comet Rotated Into the Ecliptic



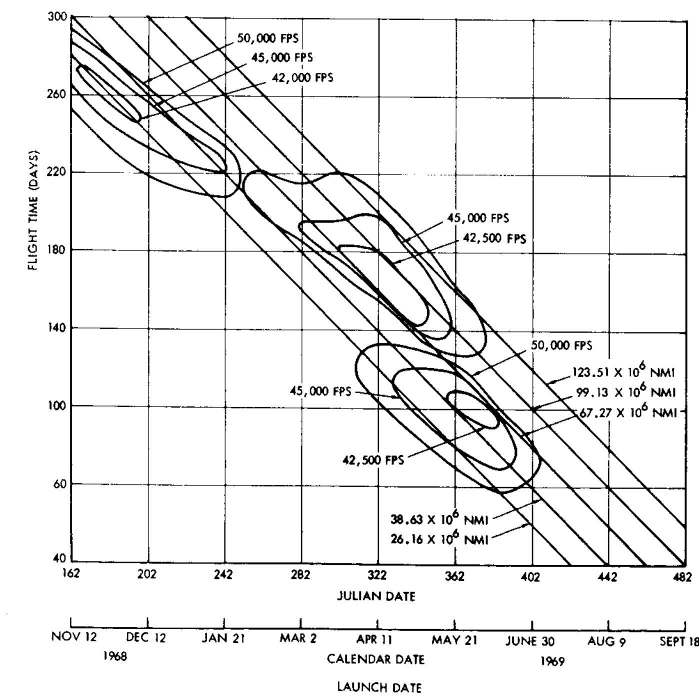

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

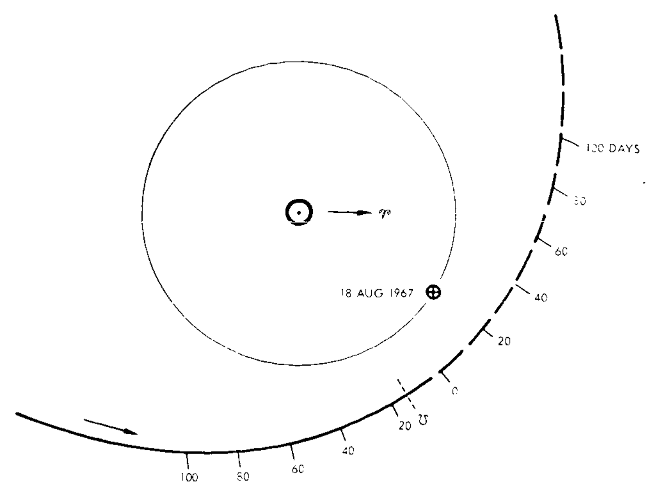
q = 0.556 AU
i = 13.2°
e = 0.815



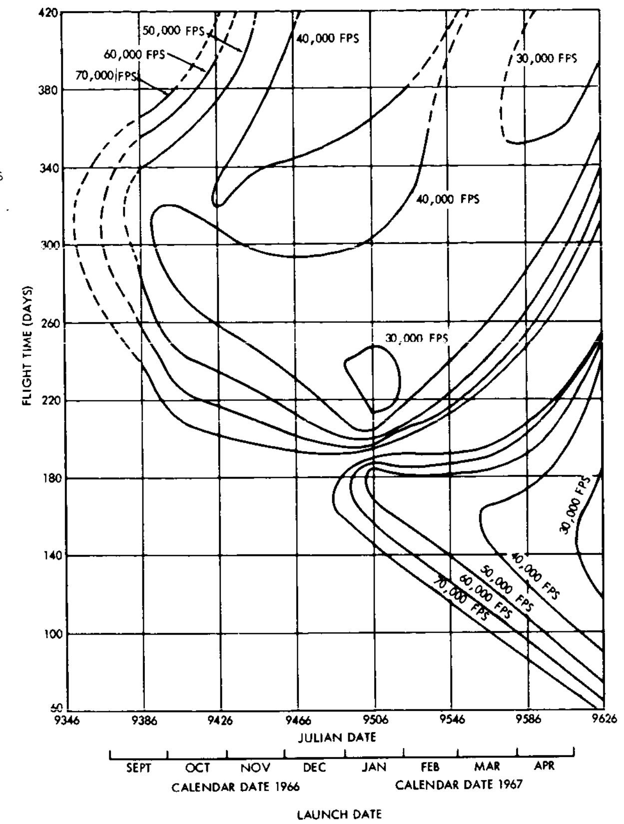

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

## TEMPEL (2)

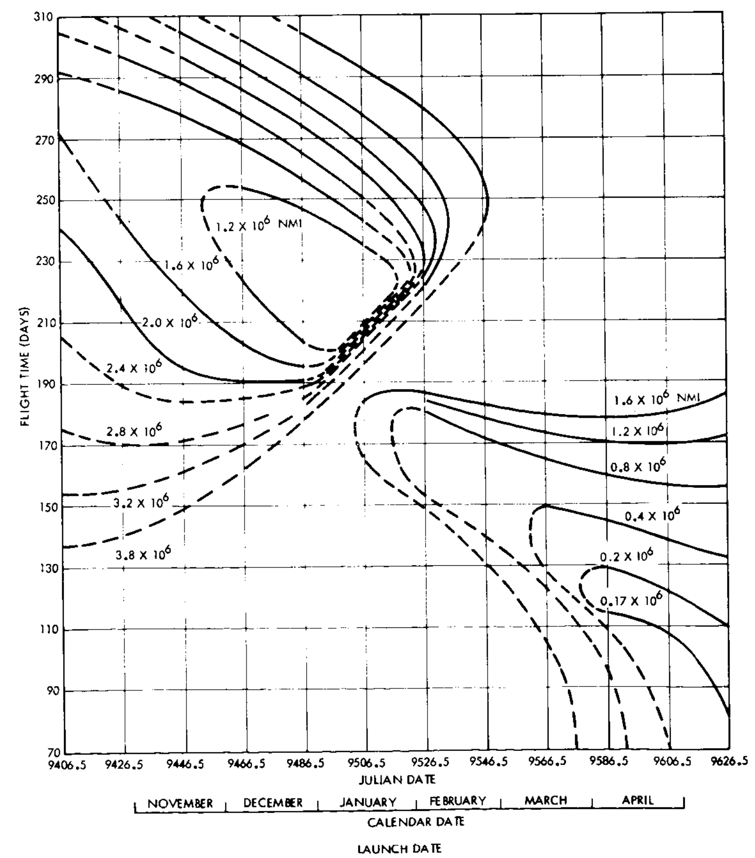
Tempel (2) is an excellent target in 1967 but a somewhat poorer target in 1972. In 1967 trajectories with injection energies as low as 38,000 fps can be used with a 2-month launch window. The flight time for these trajectories is in the order of 120–150 days. If the injection velocity is permitted to go to 50,000 fps, the launch window is more than 4 months and the flight time can be brought below 100 days. The transmission distance is also minimum near minimum energy, about 35 million miles. Closing velocities can be selected over this launch interval and vary between 70,000 to 30,000 fps. Miss distances are very small, as low as 200,000 miles, even for the large errors assumed. Since Tempel (2) is inclined by 12.5 degrees, miss coefficients will not be substantial.




Path of the Comet Rotated Into the Ecliptic



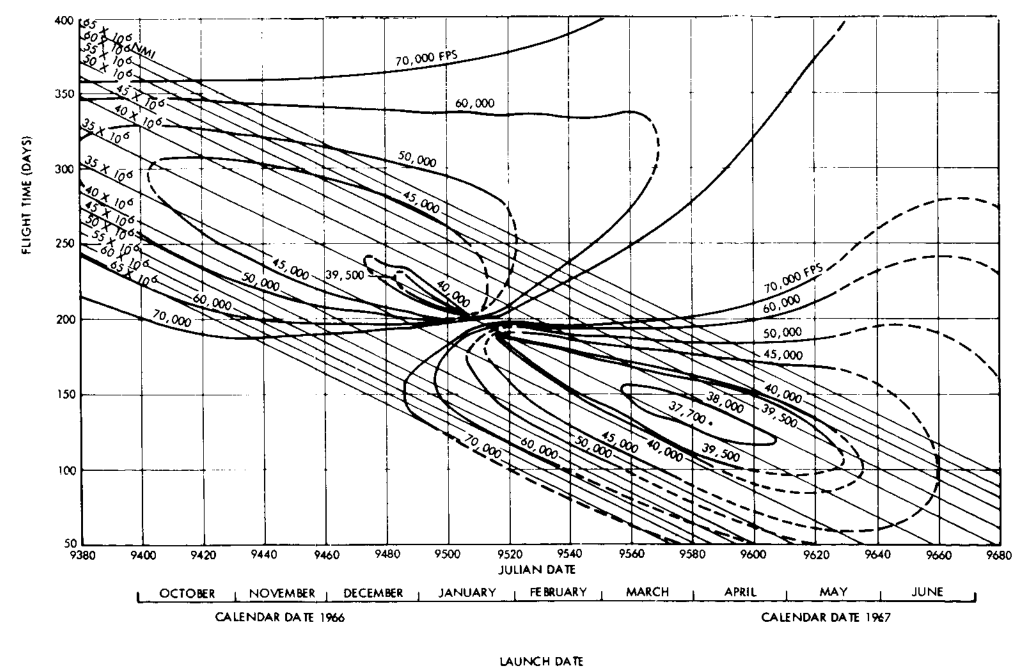

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

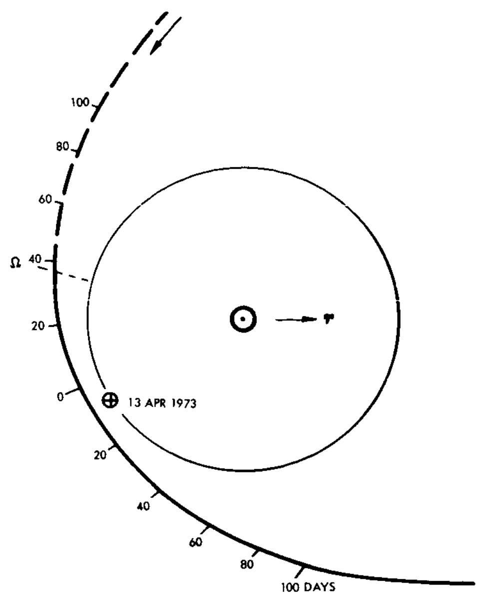
q = 1.369 AU
i = 12.5°
e = 0.548



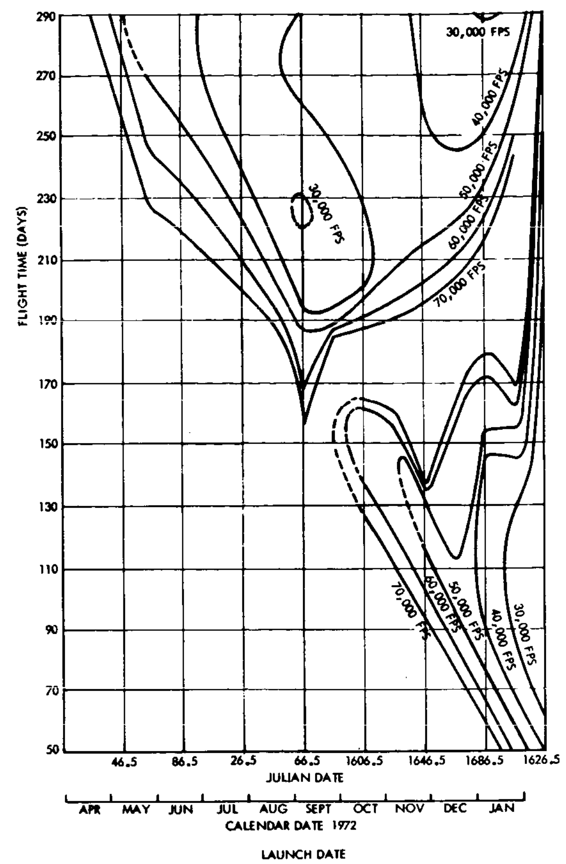

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177 nmi)

## TUTTLE-GIACOBINI-KRESAK

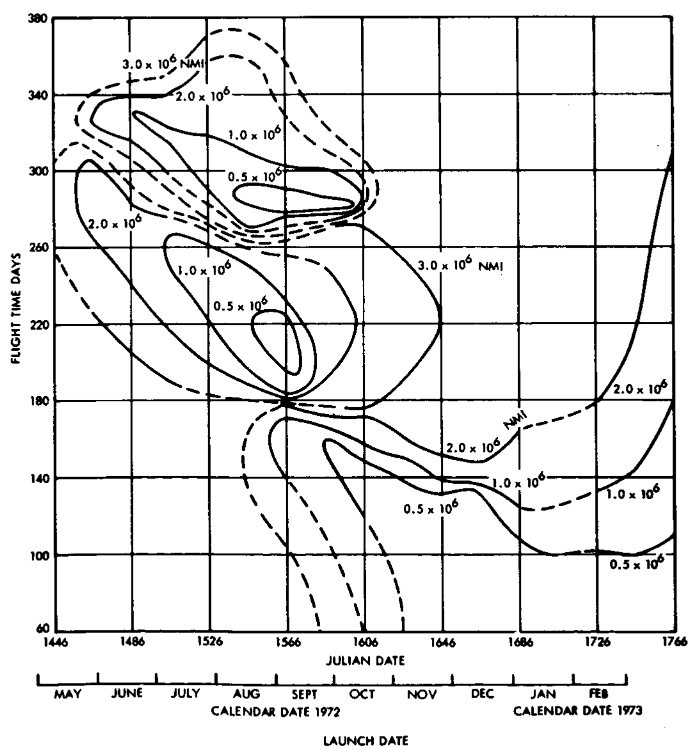
Tuttle-Giacobini-Kresak is an excellent comet for intercept in its 1973 apparition. Minimum velocity, even for the Class I trajectories, is 37,500 fps and the flight time is 90 days. The launch window for under 38,000 fps is about 3 months and the transmission distance at intercept is around 15 million miles. Closing velocities for these trajectories can vary anywhere between 70,000 fps and 30,000 fps, and this choice is fairly insensitive to flight time. Again, the uncorrected miss distance can be kept as low as 500,000 miles, even for the large injection errors assumed. The low injection velocity is in large part due to the fact that intercept occurs near the node and so out-of-plane component is also low. However, it can be substantial since the orbit is inclined by almost 14 degrees.



Path of the Comet Rotated Into the Ecliptic



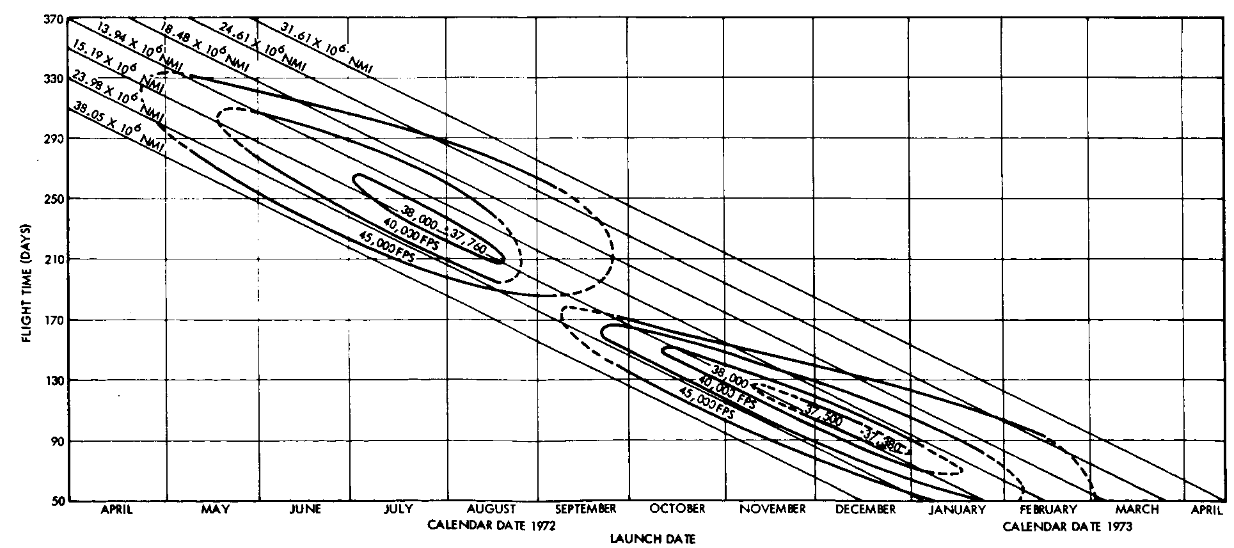
Closing Velocity Contours



Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

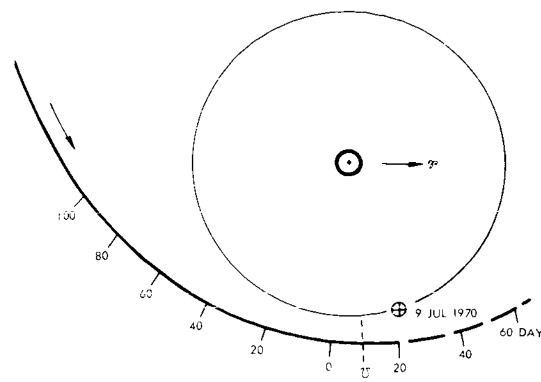
q = 1.117 AU
i = 13.8°
e = 0.641



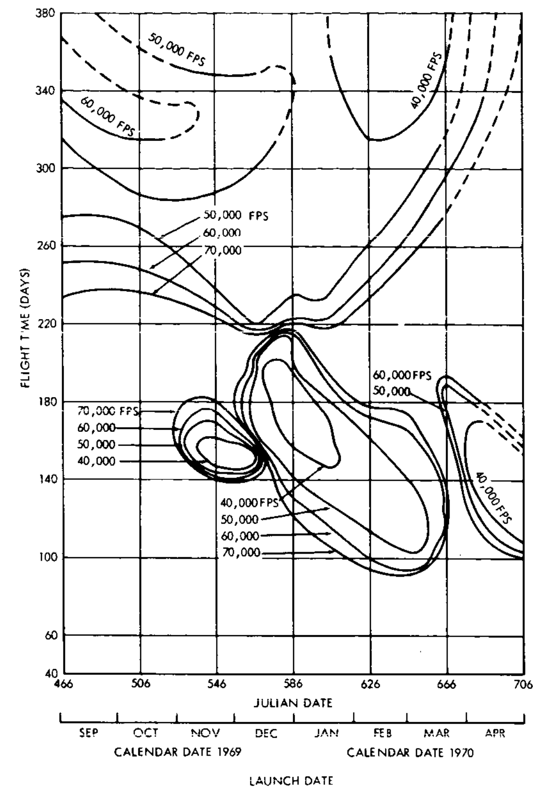
Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

## PONS-WINNECKE

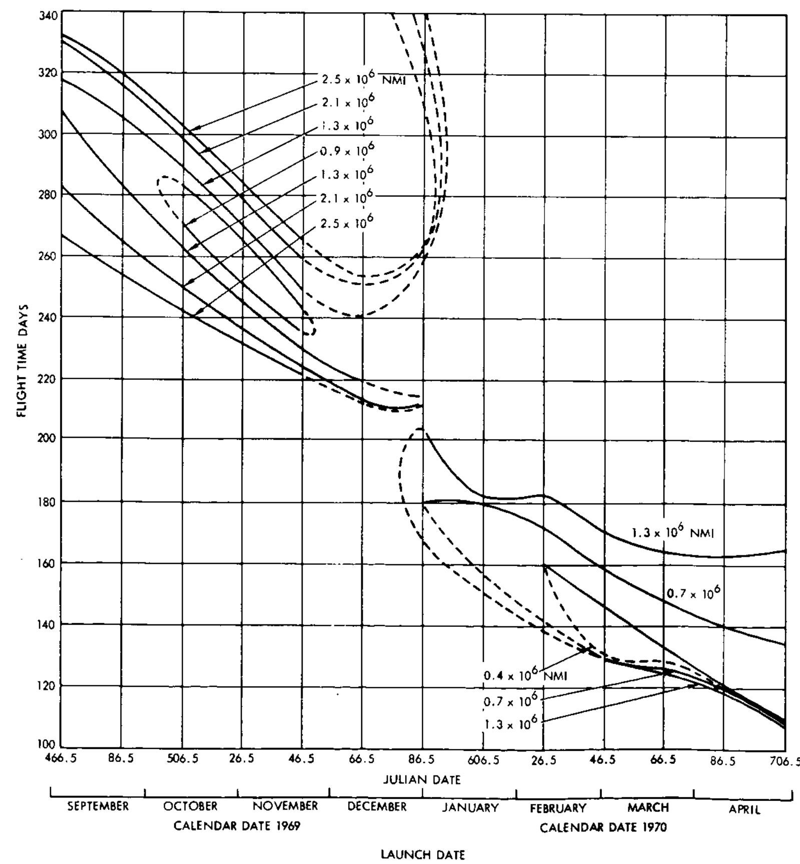
Pons-Winnecke presents a good target in 1970 but is substantially less good in 1964 and 1976. In 1970, with a minimum injection energy of 37,000 fps, there is a launch window of almost 2 months and the flight time can be as low as 130 days. The transmission distance is also quite good, about 35 million miles. The closing velocities for this region will be in the order of 40,000 to 50,000 fps and the misses can be made quite small, in the order of 400,000 miles. However, since the inclination of the comet is 21.7 degrees, large miss coefficients can be anticipated.




Path of the Comet Rotated Into the Ecliptic



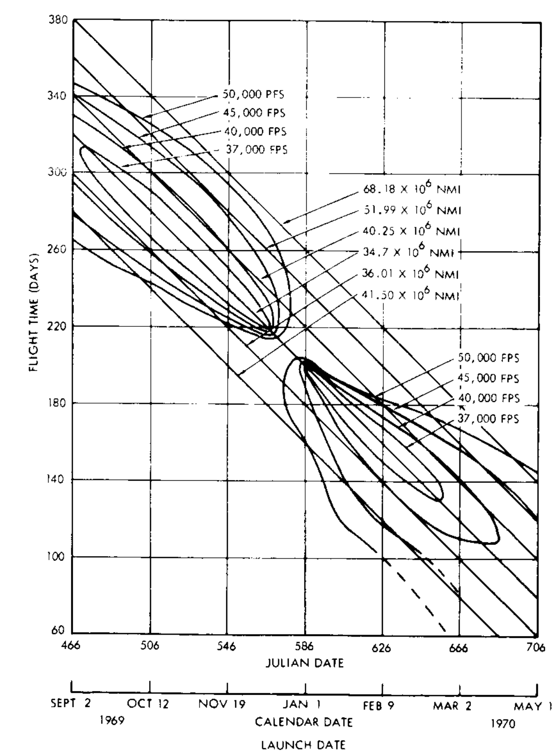

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

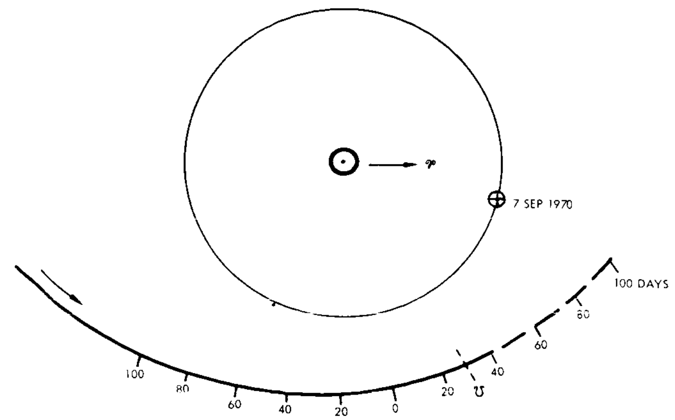
$q = 1.161$
$i = 21.7^{\circ}$
$e = 0.653$



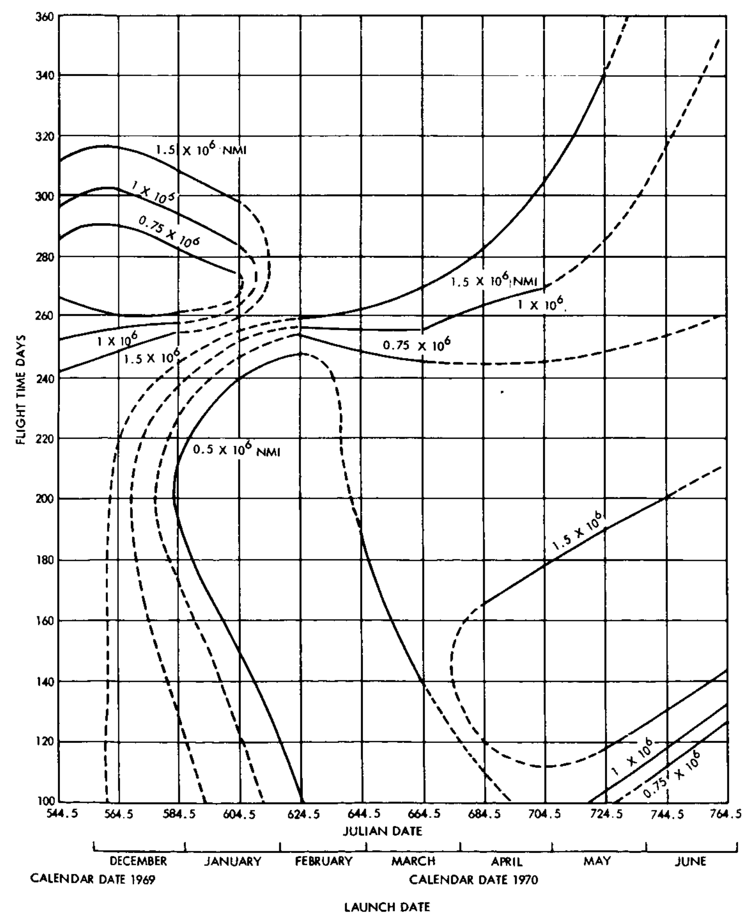

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177 nmi)

## KOPFF

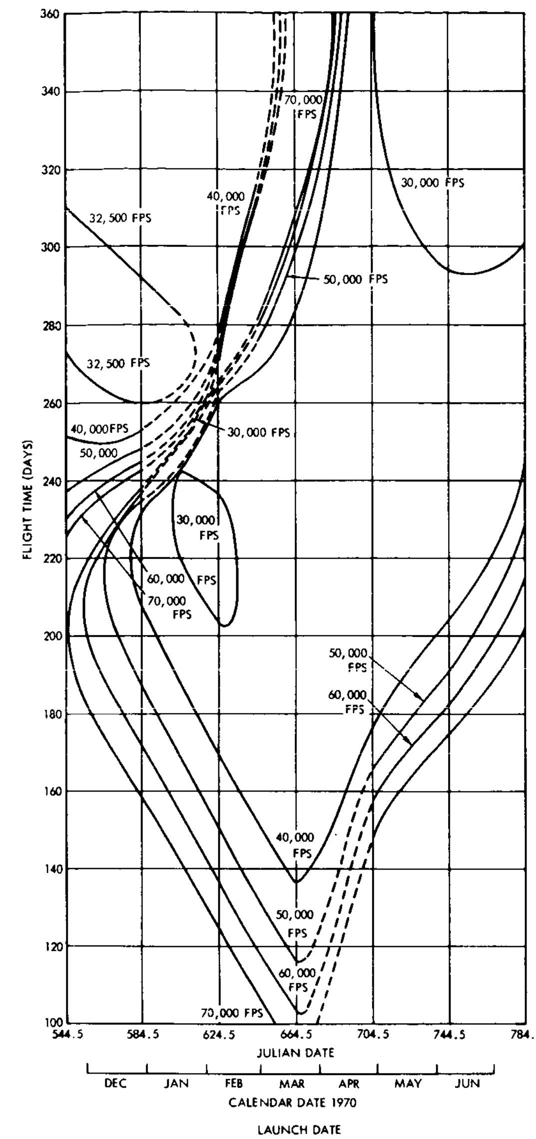
Kopff is excellently situated in its 1970 apparition. As shown on the injection velocity figure, 38,000 fps is possible with a flight time of about 220 days and that with as much as 43,000 fps, the flight time can be reduced to 140 days. The launch window at this velocity and this flight time is only 1 month long but it can easily be opened up 2 months if a 160-day flight time is allowed. We can see by the shape of the injection velocity curves on the right-hand portion of the figure that the approach conditions are quite asymtotic and that the launch window and flight time can be greatly increased using the same injection velocity. A related effect can also be recognized on the closing velocity figure where a wide range of launch dates result in the same closing velocity. Another interesting effect, due largely to the low eccentricity, is the fact that on a given launch date for a wide range of injection velocities, the same closing velocities are achieved for a wide range of flight times. The trajectory, as shown on the miss curves, is quite insensitive to the launch date, which is largely the result of the low comet inclination.




Path of the Comet Rotated Into the Ecliptic



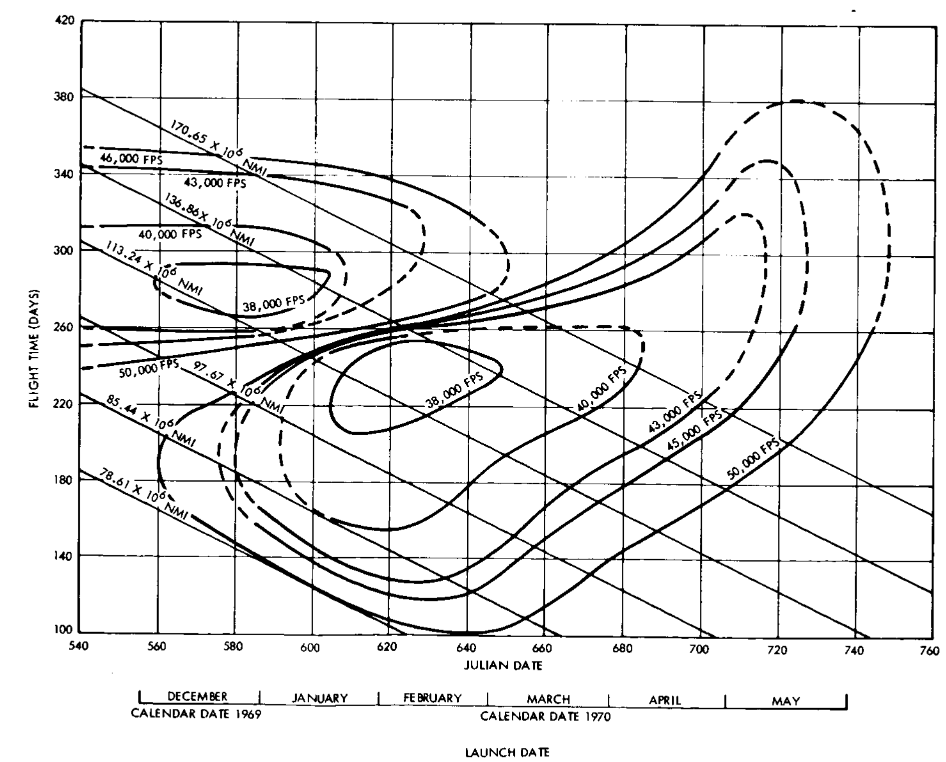

Miss Distance Resulting From Uncorrected Errors at Injection




Closing Velocity Contours

Legend:

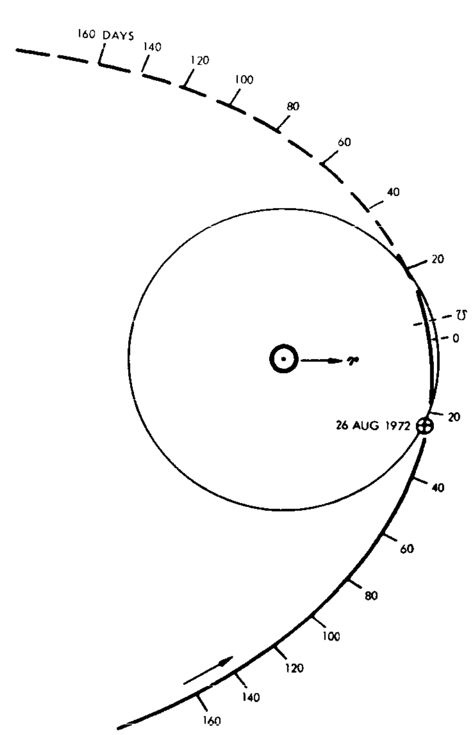
q = 1.516 AU
i = 4.7°
e = 0.556



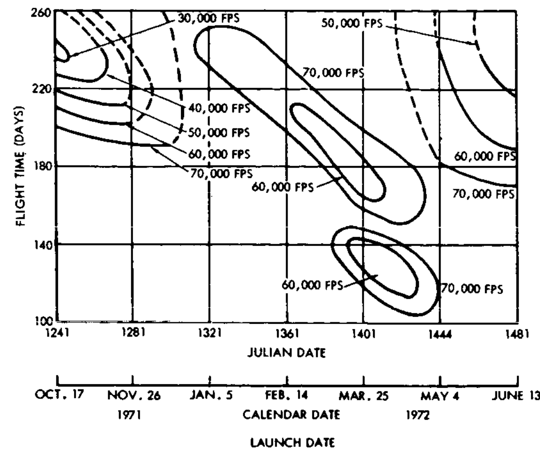

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

# GIACOBINI-ZINNER

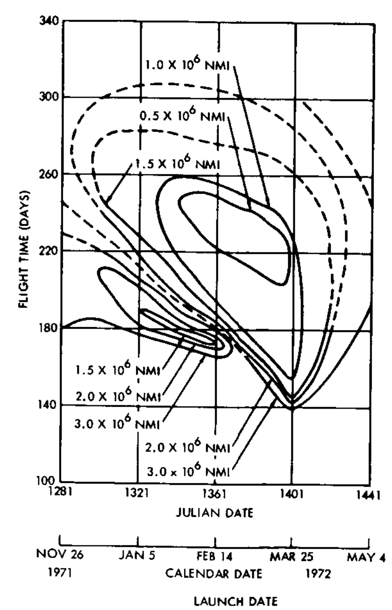
Giacobini-Zinner presents a fairly good target in 1972 but is considerably less good in 1976. With velocities in the order of 45,000 fps, there is a launch window of 2 months and flight times will vary between 120 to 160 days. For Class II trajectories, with 37,500 fps, there is a launch window of almost 5 months and the flight time will range between 180 to 300 days. The closing velocities for Class I trajectories will be quite high, a minimum of 60,000 fps, and is the same for the low flight times in Class II trajectories. Although the miss distance need not be large, as small as 500,000 miles, the inclination of 30.9 degrees means that the miss sensitivities will be very large.




Path of the Comet Rotated Into the Ecliptic



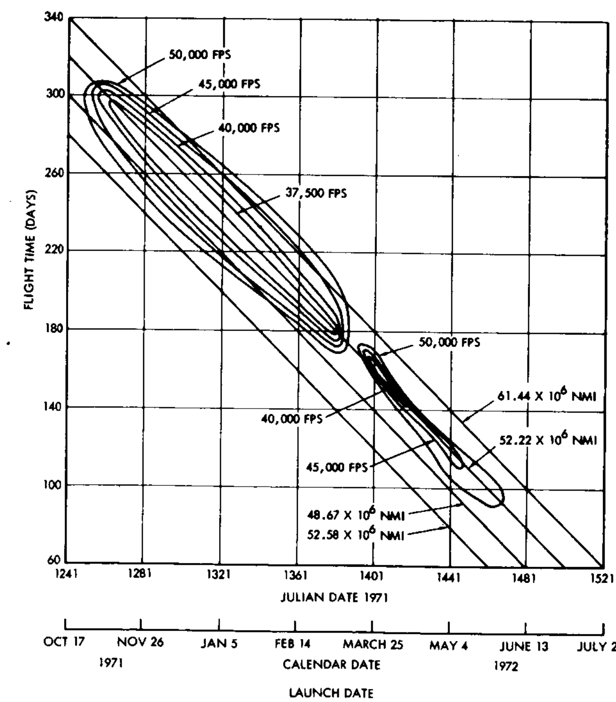

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

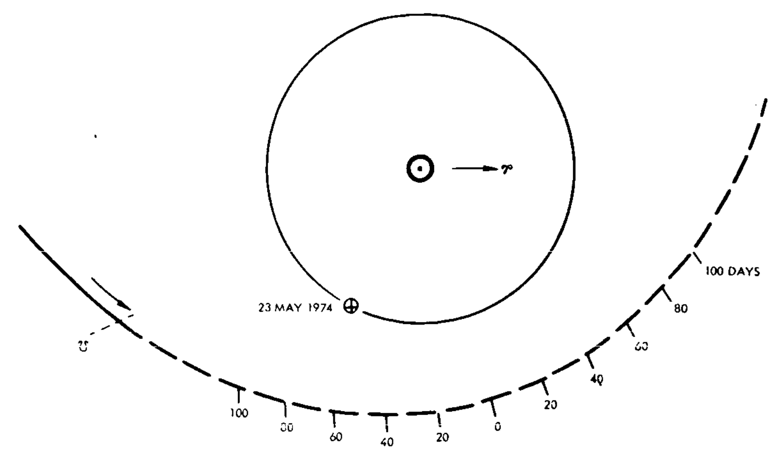
q = 0.936 AU
i = 30.9°
e = 0.729



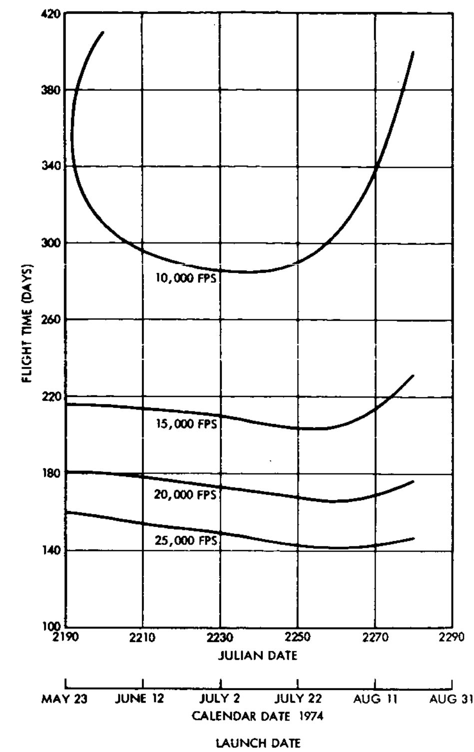

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

## FORBES

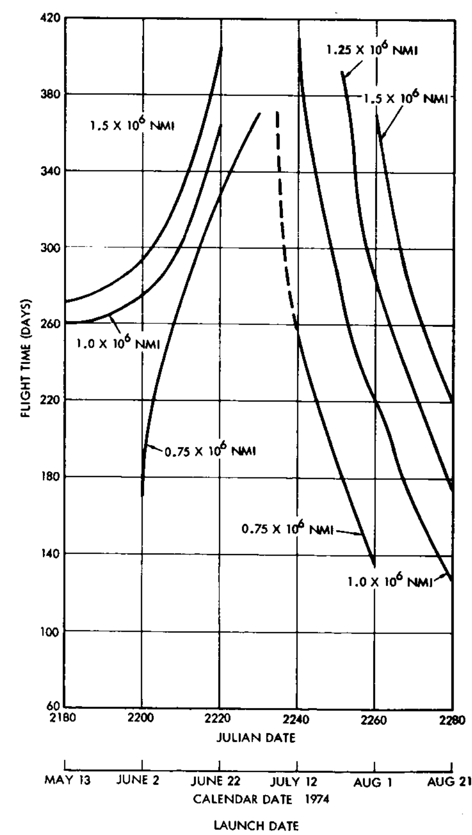
Forbes presents a fairly good target in 1974 but a rather poor target in 1967. The velocity requirements for a mission to Forbes are substantial, the minimum being approximately 47,500 fps. The launch window for this velocity is only about 1 month. Since Forbes is about 0.5 AU from the earth at perihelion, transmission distances are large. However, because of the location of the earth and the comet in 1974, the flight times for the same velocities can be extremely large. A corollary of this is that the closing velocities are almost exclusively a function of flight time and generally decrease with flight time. Hence for a long flight time in the order of 350 days, the closing velocity can be as low as 10,000 fps. The miss distance for this comet can readily be kept below 750,000 nmi. Since it is inclined by only 4.6 degrees, miss sensitivities can be expected to be small.




Path of the Comet Rotated Into the Ecliptic



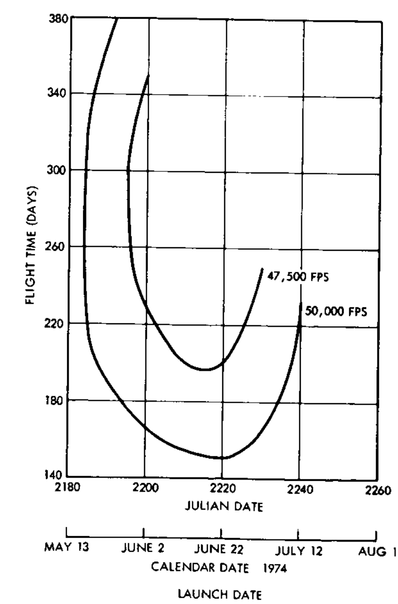

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

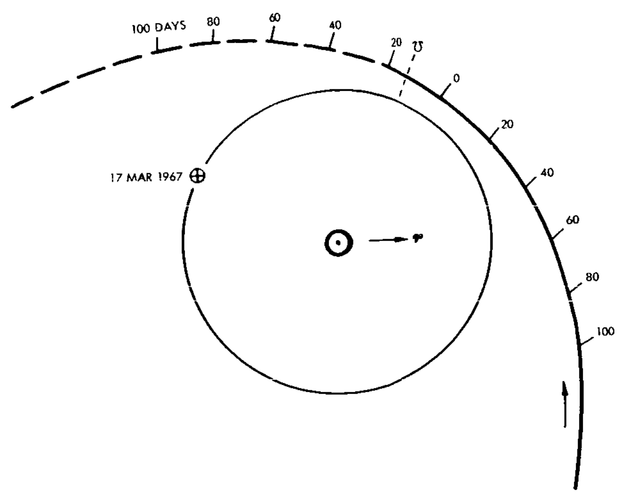
Legend:

q = 1.545 AU
i = 4.6°
e = 0.553

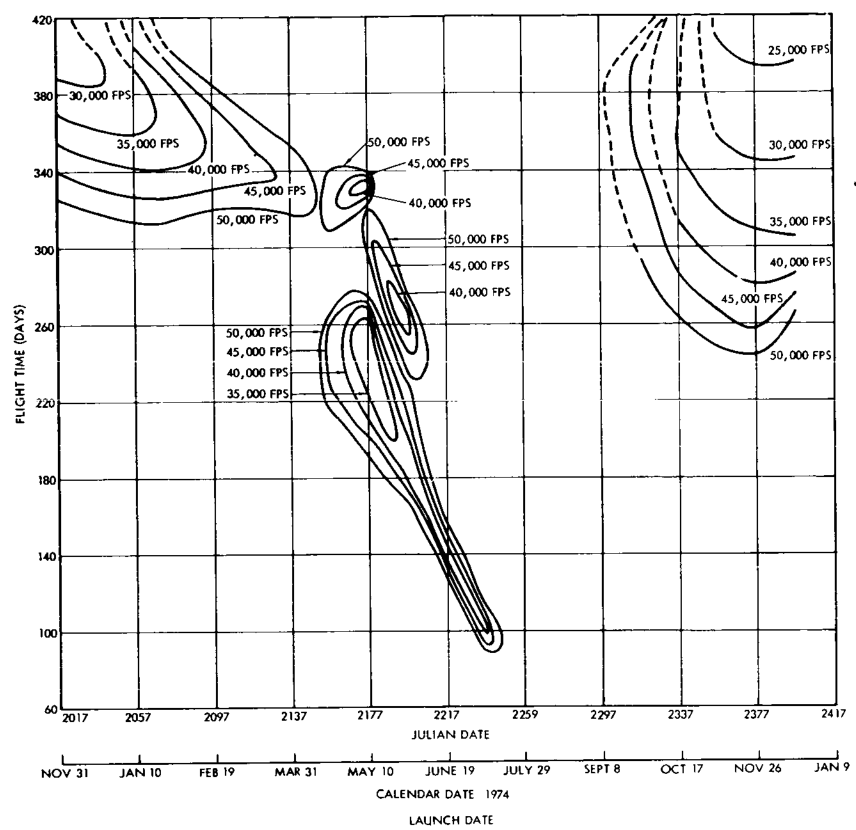



Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

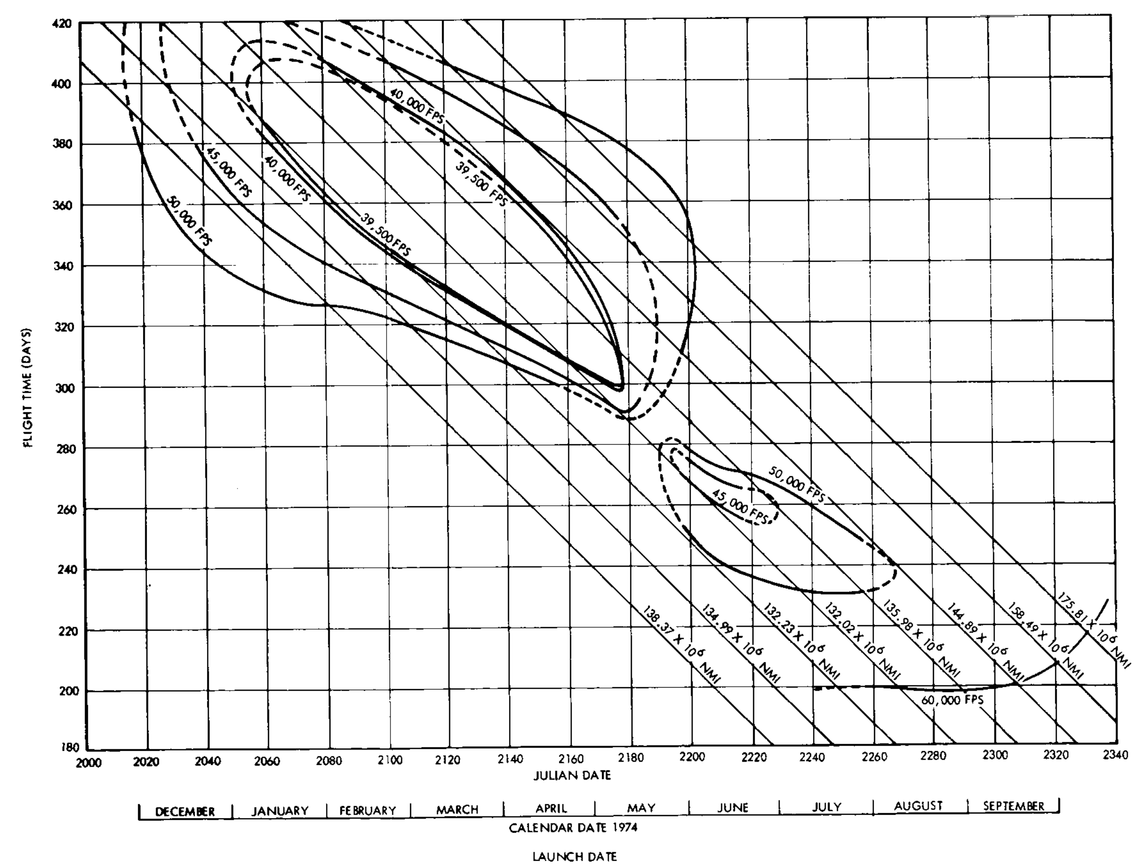
Perrine-Mrkos is poorly situated both in 1968 and 1975, and can only be intercepted with very long flight times. The minimum injection velocity for a Class I trajectory in 1975 is in the order of about 45,000 fps. With this velocity, the launch window is only 1 month. For the much longer Class II trajectories, however, low velocities in the order of 42,000 fps give many months of launch window. With this injection velocity, the closing velocities are in the order of 50,000 fps to 30,000 fps. The miss distance for the Class I trajectories is between 3–5 million miles, and for the Class II it is in the same order. In terms of the lifetime requirements on the spacecraft, it is quite clear that this comet will be a poor target in 1975. Also, since the inclination is approximately 16 degrees, fairly large miss coefficients can be expected.



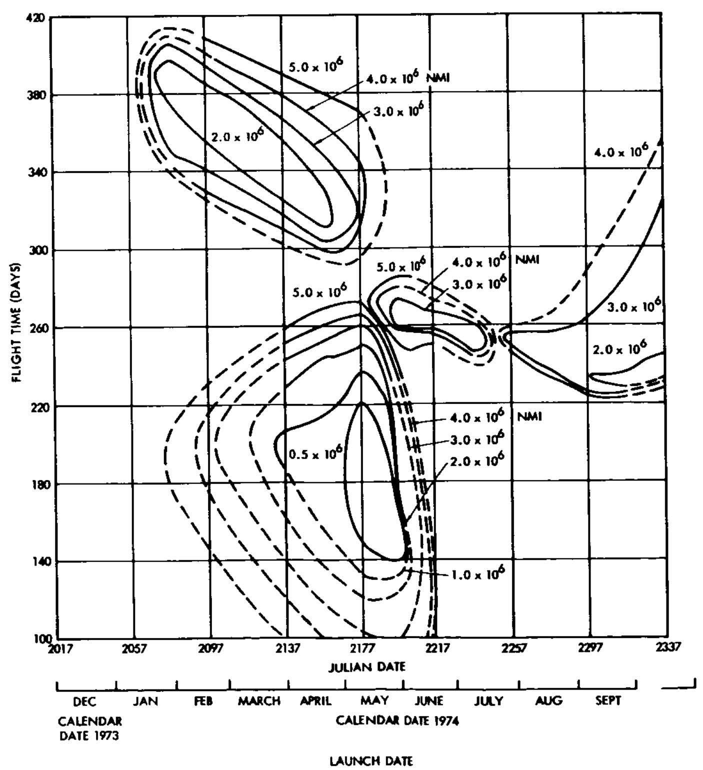

Path of the Comet Rotated Into the Ecliptic




Closing Velocity Contours




Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)



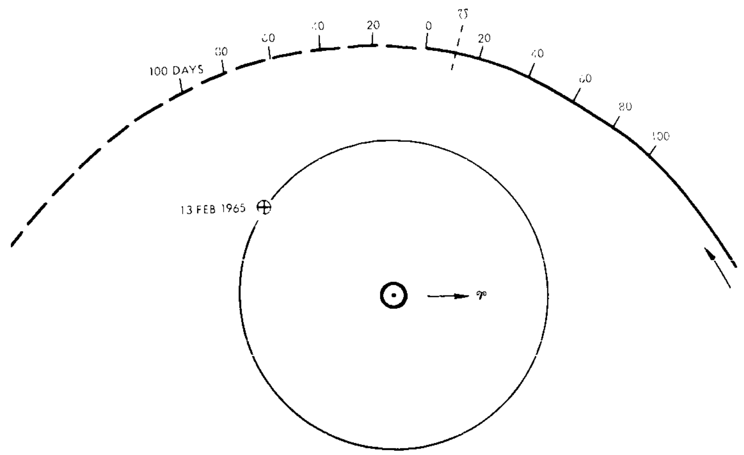

Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

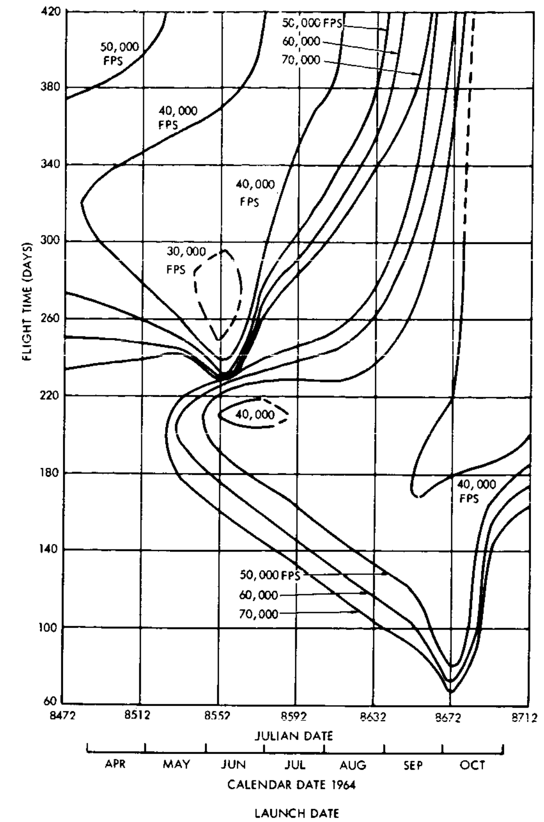
q = 1.154 AU
i = 15.9°
e = 0.667

## WOLF-HARRINGTON

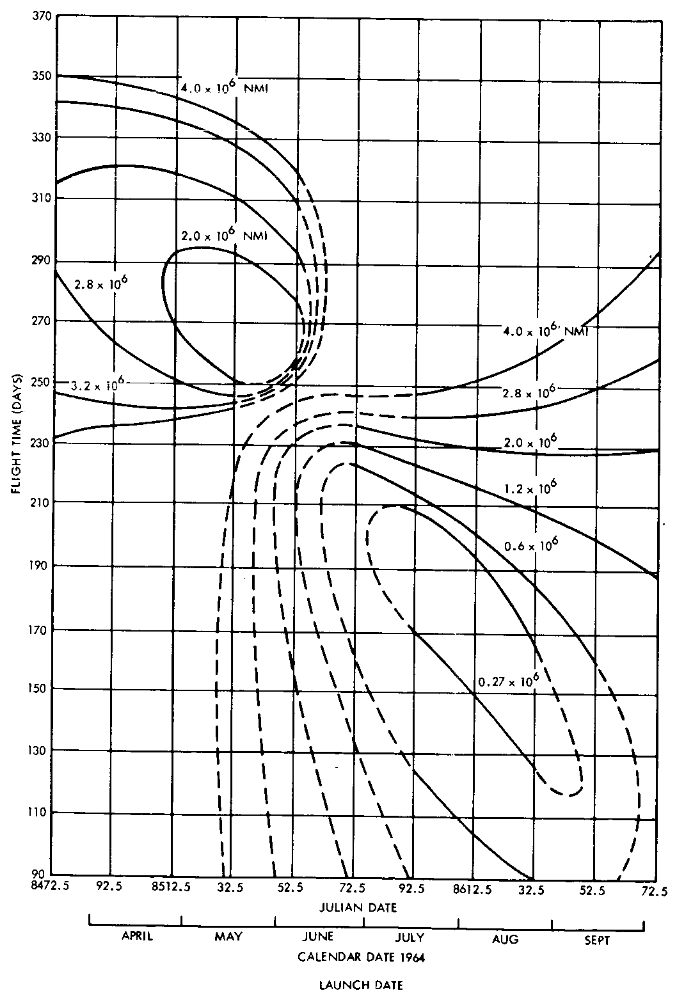
Wolf-Harrington is an excellent target in 1965 and can be reached with a minimum velocity of 38,000 fps. At 40,000 fps there is a 2 month launch window and the flight times range between 160 to 230 days. The transmission distance at intercept is of the order of 100 million miles which, although long, is satisfactory. The closing velocity for the Class I trajectories is insensitive to flight time which can be expected for an orbit which is not very eccentric. Miss distance can vary by a factor of 16 during the launch interval of greatest interest but can easily be minimized. However, since the orbit is inclined by 18.5 degrees, we can anticipate very sensitive miss coefficients.




Path of the Comet Rotated Into the Ecliptic



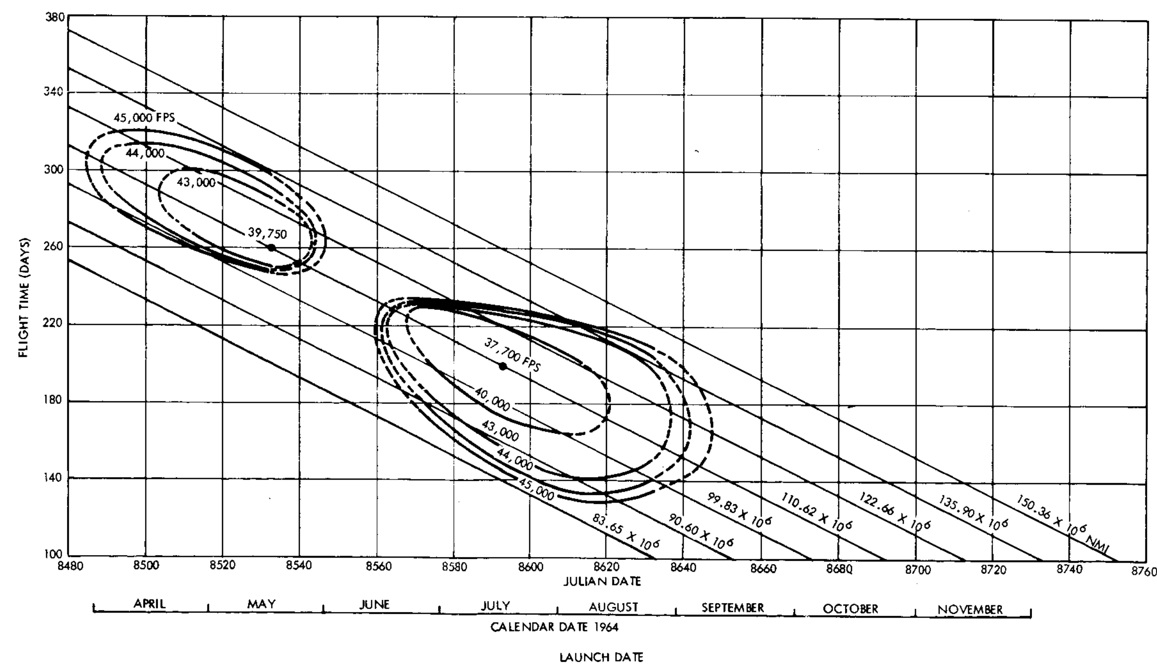

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

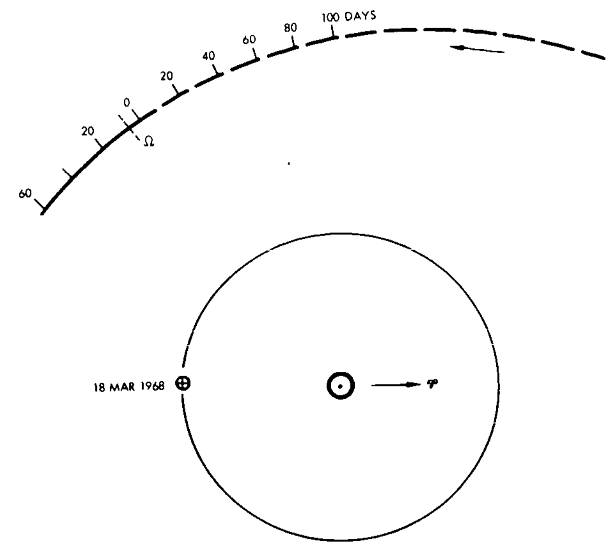
q = 1.604 AU
i = 18.5$^{o}$
e = 0.540



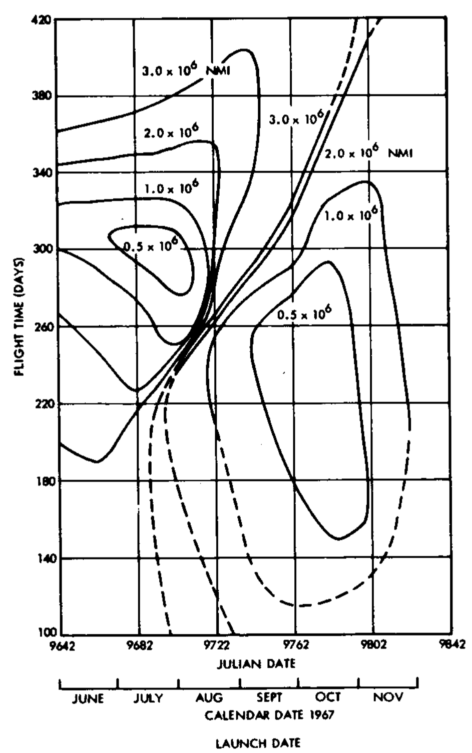

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

# SCHWASSMANN-WACHMANN (2)

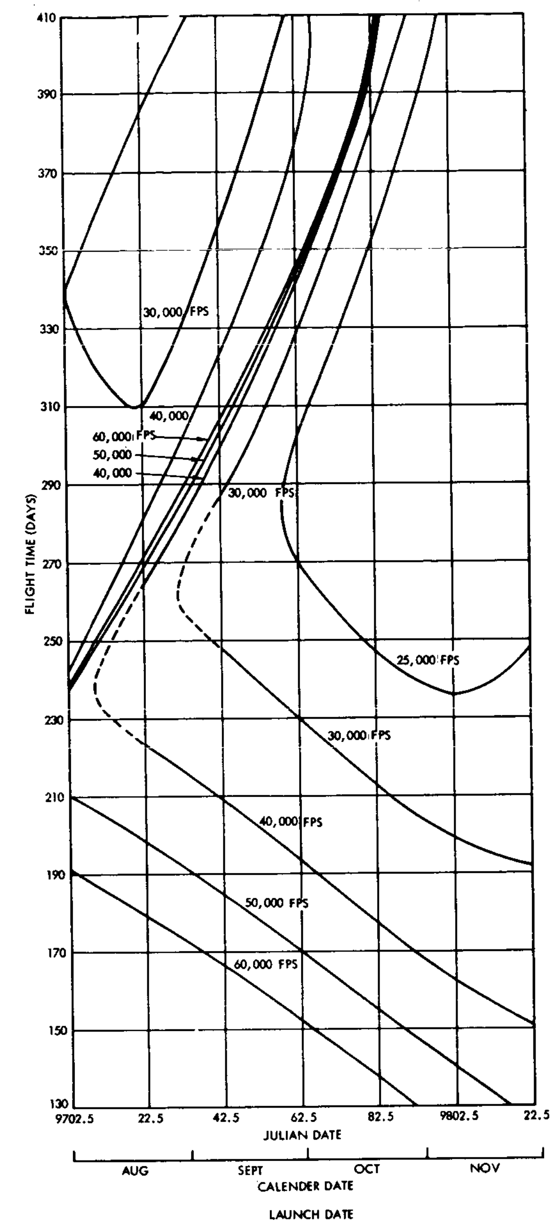
Schwassmann-Wachmann (2) presents a fair target during 1968 with a minimum energy of about 40,000 fps and with about 2 months of launch window at 42,000 fps. However, since it does not come very close to the earth, the minimum transmission distance is 220 million miles. The wide range of flight times, 140–300 days, for the same injection velocity indicate that an asymptotic approach is possible, especially for launches in October or November. This same effect can also be seen on the closing velocity curve where, with essentially the same injection velocity and the same launch day, the closing velocity can be changed by as much as 40,000 fps. The general symmetry of the miss distance contours suggests that the effects of injection errors can readily be minimized.




Path of the Comet Rotated Into the Ecliptic



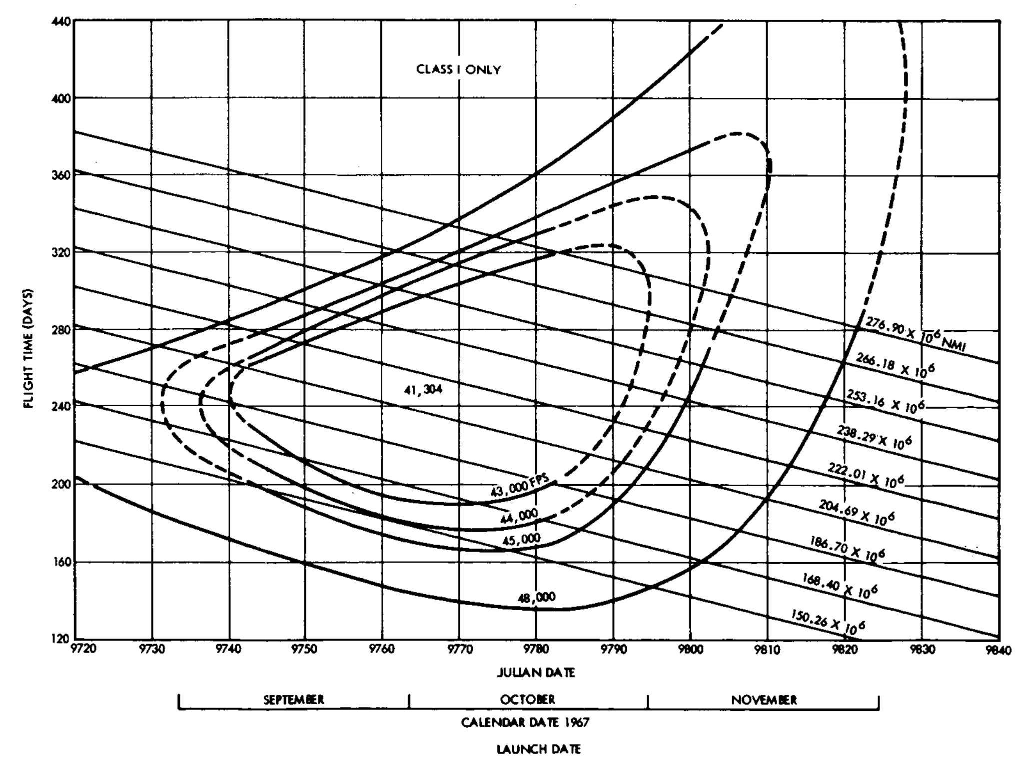

Miss Distance Resulting From Uncorrected Errors at Injection




Closing Velocity Contours

Legend:

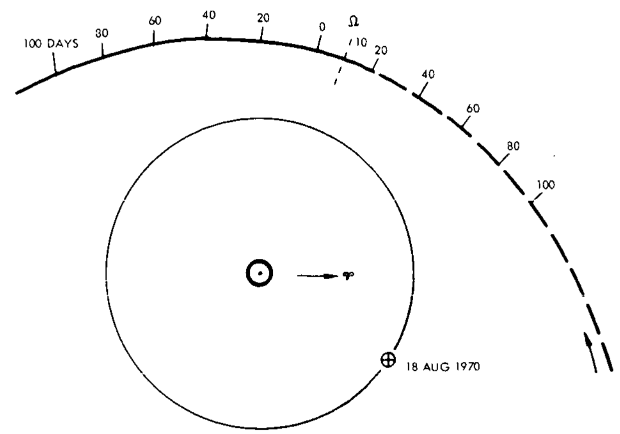
q = 2.157 AU
i = 3.7°
e = 4.83



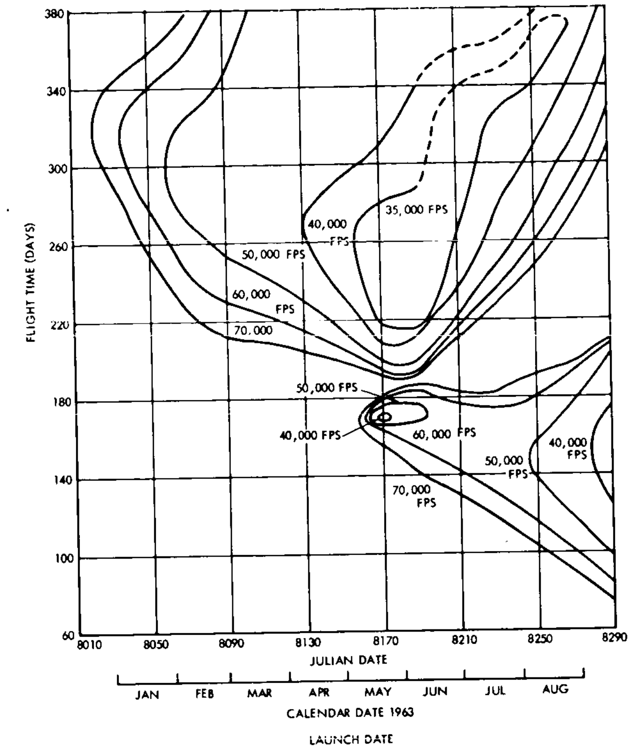

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

## DANIEL

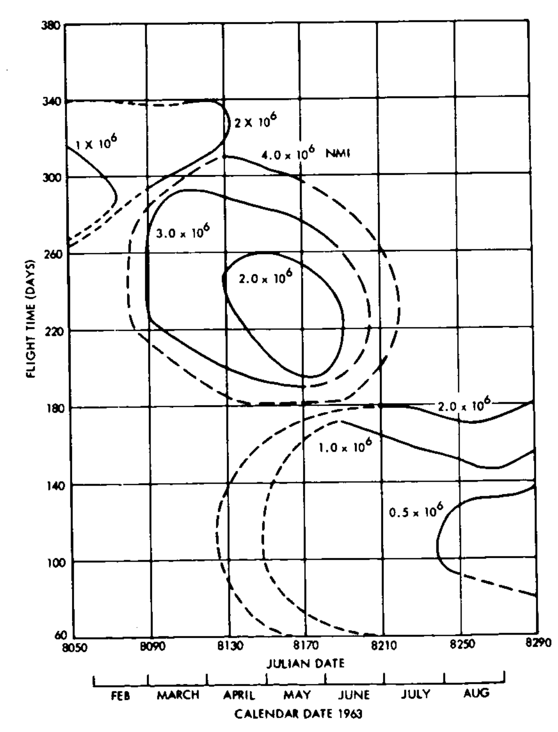
Daniel presents a good target in 1963 and perhaps a better target in 1977. However, it is a poor target in 1970. In 1963, with velocities of 43,000 fps, there is a 3-month launch window and flight times can be as low as 100 days. Transmission distance is also minimized at around 40 million miles. During the possible launch interval, approach velocities vary from 40,000 to 60,000 fps, and miss distances vary from 500,000 to 1 million nmi. However, since it is inclined by 19.7 degrees, the miss coefficients will be quite large.




Path of the Comet Rotated Into the Ecliptic



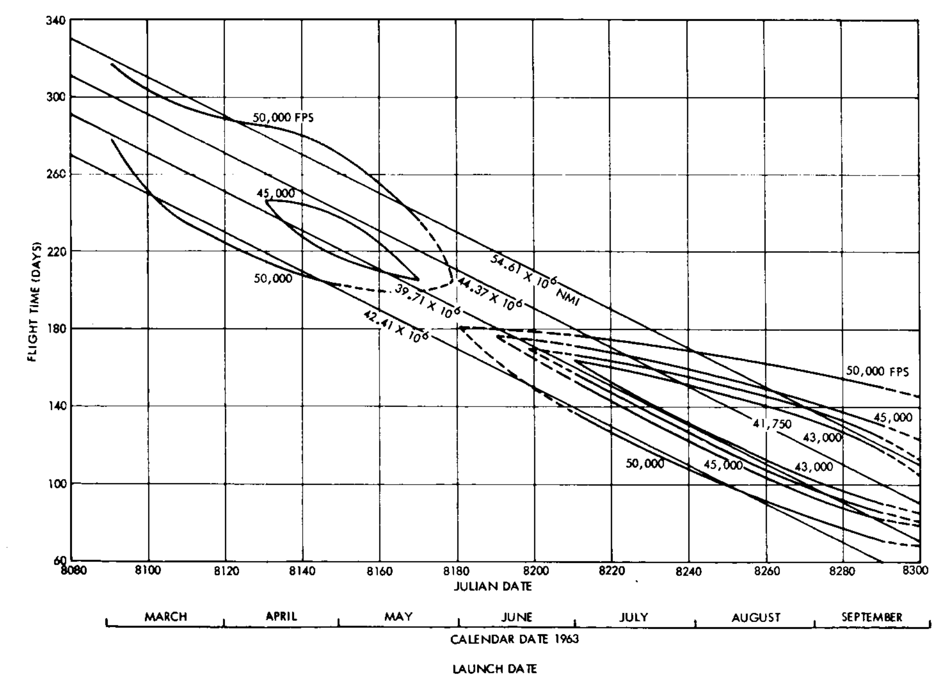

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

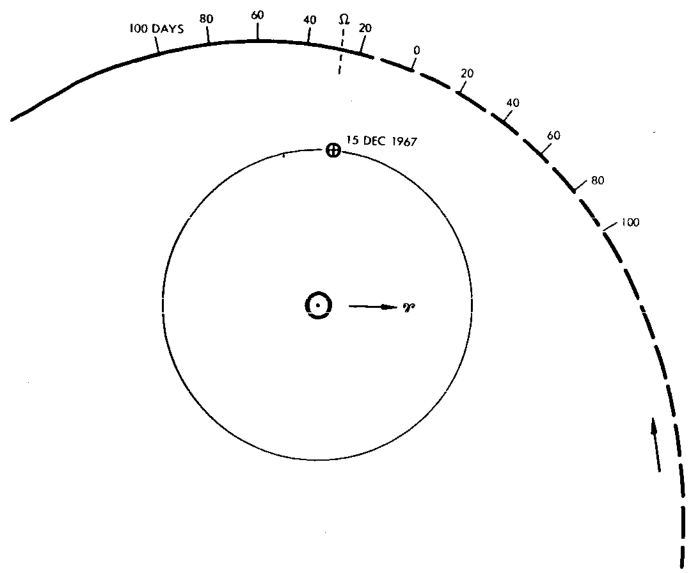
q = 1.465 AU
i = $19.7^{o}$
e = 0.586



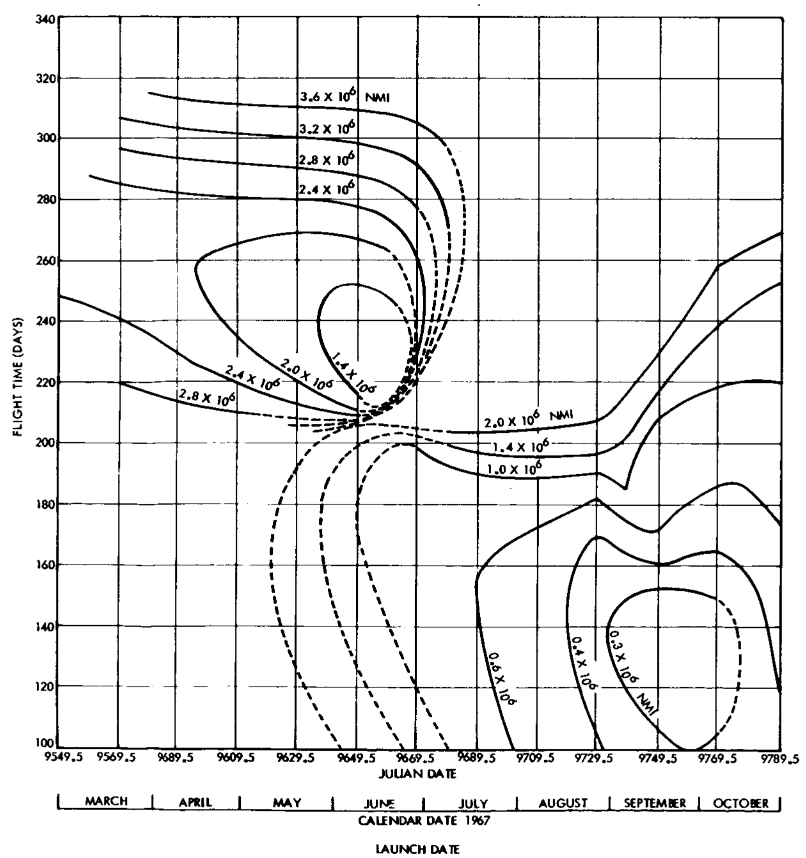

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

# WIRTANEN

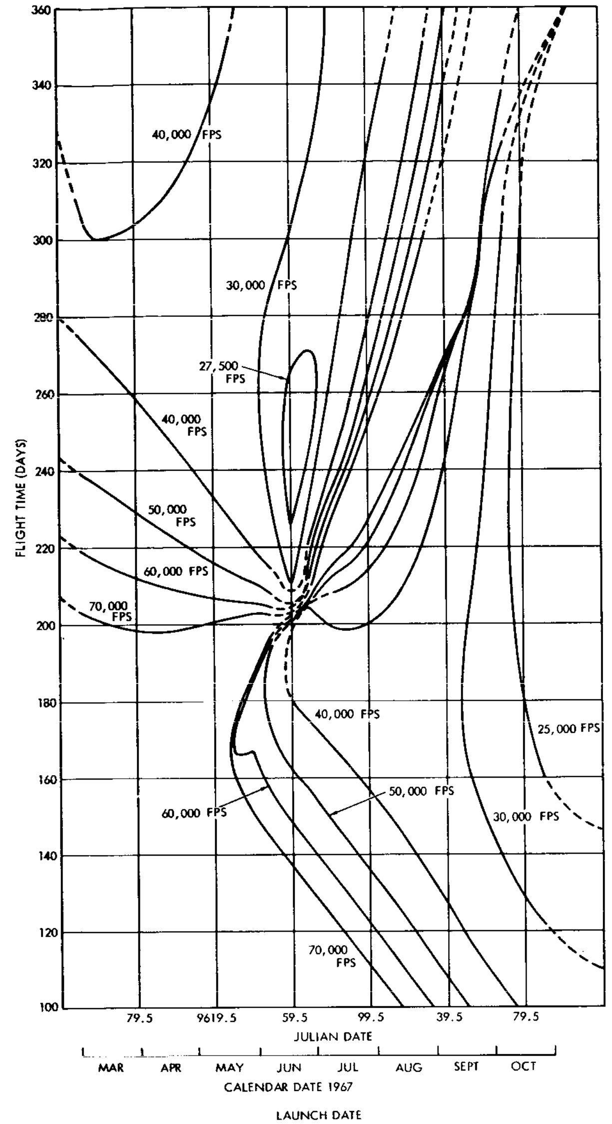
Wirtanen will be an excellent target in 1967 but considerably less good in 1974. With an injection velocity of 41,000 fps, a launch window of 2 months is available and flight times can be as low as 129 days. Moreover, intercept will occur at such a time that near minimum transmission distances of 60 million miles can be achieved. For launches in August and September, the minimum energy times the closing velocities will be as low as 30,000 fps or as high as 50,000 fps, regardless of the injection velocity. Equally important is the fact that the uncorrected misses for this comet can be very small—300,000 miles, even with the large errors assumed. Since the comet is inclined by 13.4 degrees, the miss coefficients will not be very large.




Miss Distance Resulting From Uncorrected Errors at Injection



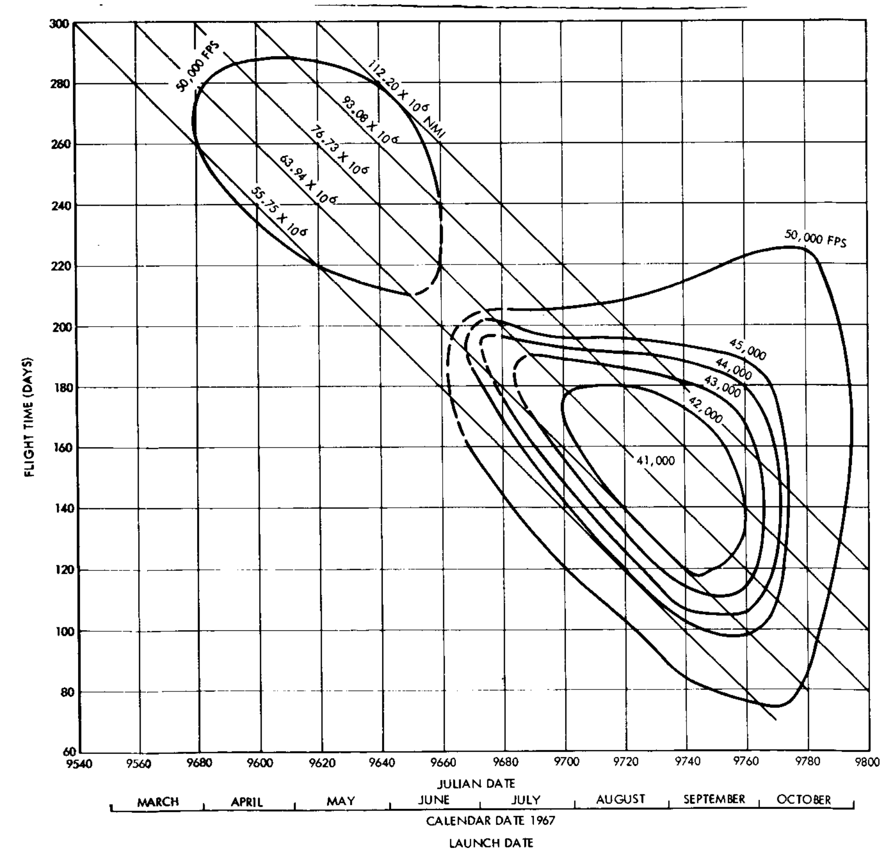

Miss Distance Resulting From Uncorrected Errors at Injection




Closing Velocity Contours

Legend:

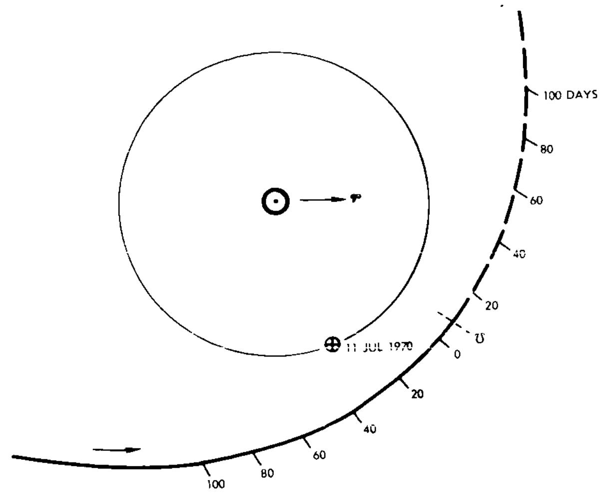
$q = 1.618$
$i = 13.4^{\circ}$
$e \approx 0.543$



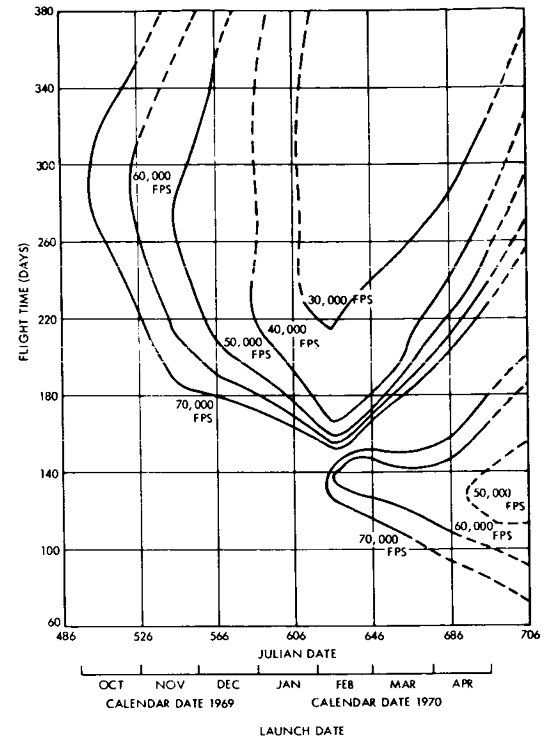

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

## D'ARREST

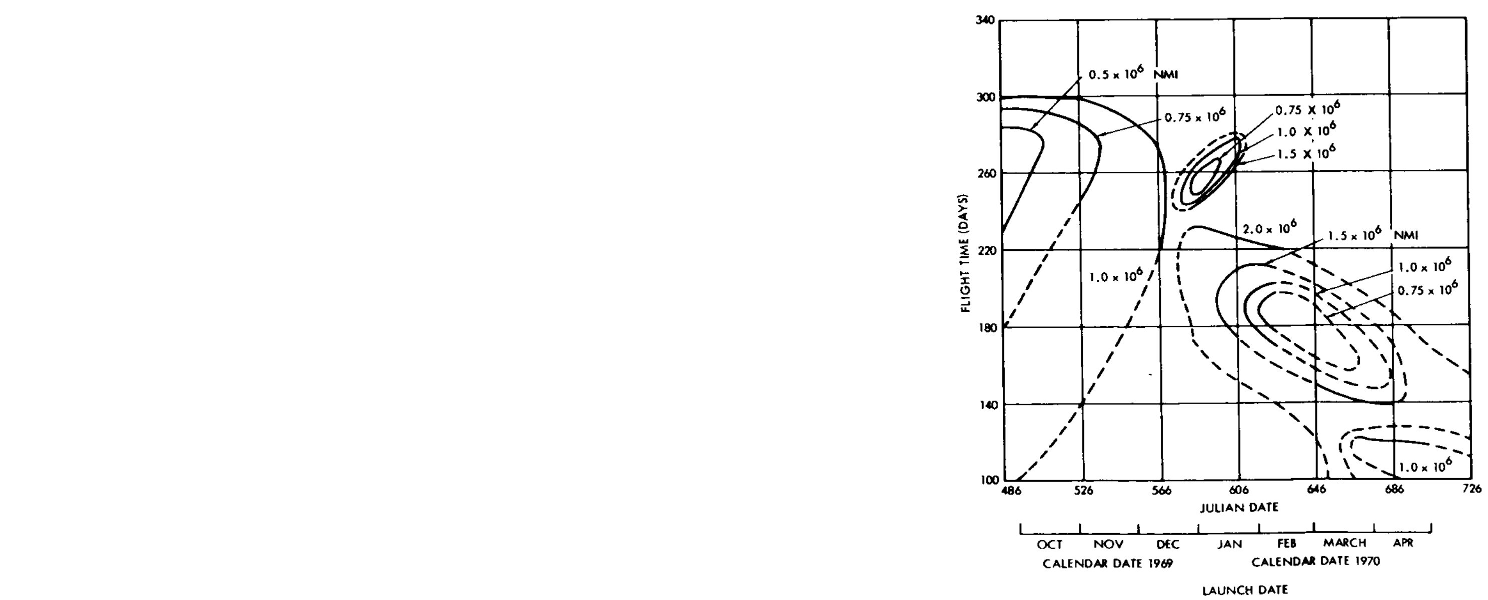
D'Arrest, shown for a 1970 intercept, must be launched about 7 months prior to perihelion passage and even the minimum flight time for the minimum velocity is 220 days. Velocity requirements for Class I trajectories with their shorter flight times were considerably in excess of 50,000 fps. The approach velocity for the minimum energy trajectory was in the order of 50,000 fps and could be reduced to 30,000 fps if a 48,000 fps injection velocity were used. Miss sensitivities indicate that, in general, the variation expected is probably no more than a factor of 5 and hence, this is not an important consideration. The important property of this intercept is, of course, the location of the earth during the comet's approach, which is poor. The transmission distance of about 55 million miles for most intercepts is satisfactory.



Path of the Comet Rotated Into the Ecliptic



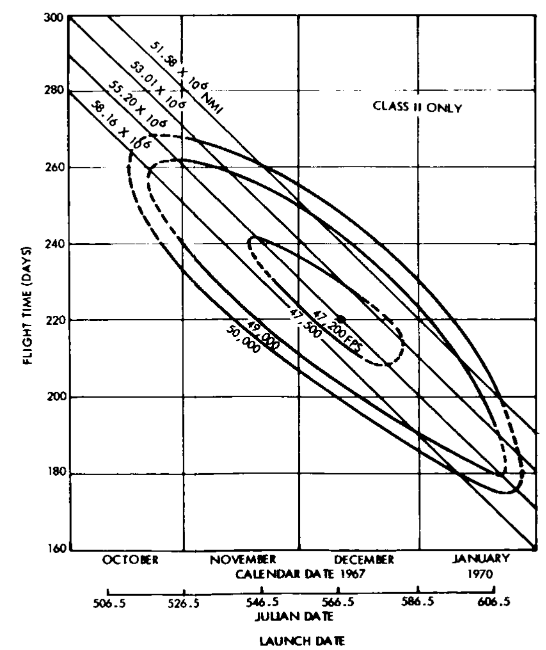

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

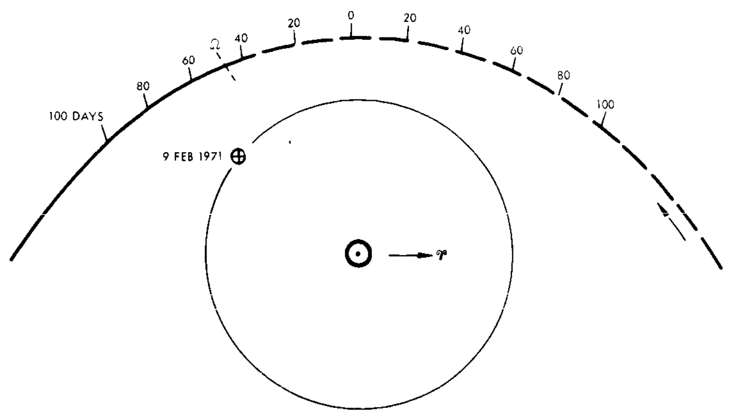
q = 1.378 AU
i = 18.1°
e = 0.612



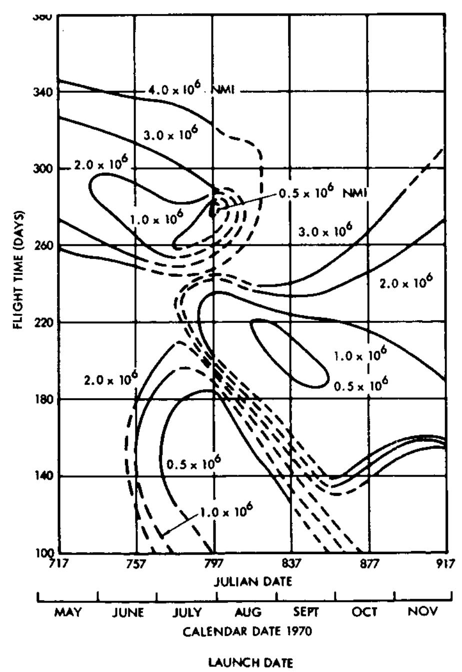

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

# AREND-RIGAUX

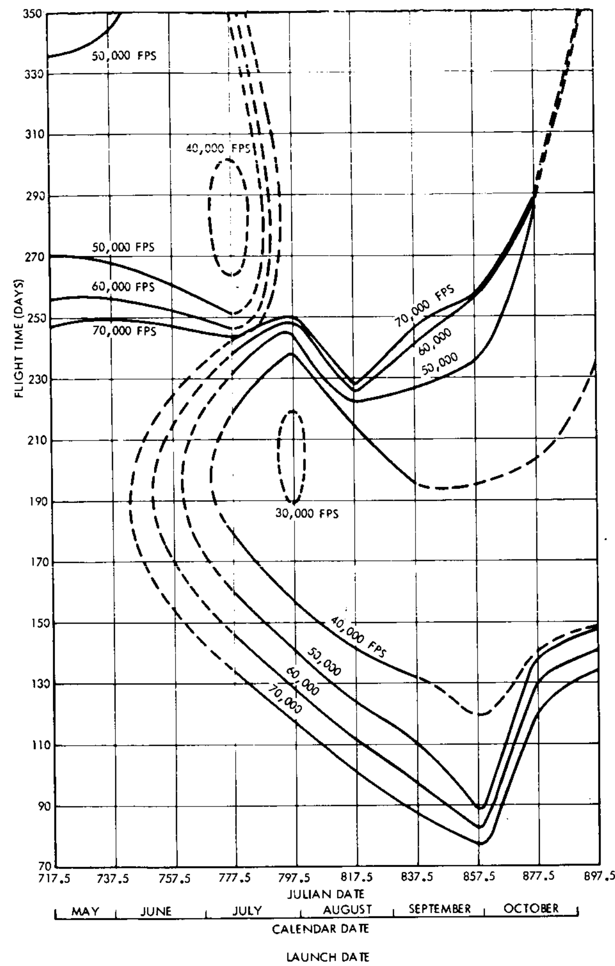
Arend-Rigaux is a good target in 1971 and a minimum energy trajectory of 38,000 fps has a launch window of almost 1 month long. With 43,000 fps, the launch window is 3 months long and the flight time ranges between 160 to 220 days. The transmission distance in these trajectories is about 107 million miles, which is long but it can be reduced to 85 million miles. However, the approach velocities for these Class I trajectories will lie in the 30,000 fps region and cannot easily be increased, if desired, without substantially increasing injection velocities. The miss distance for these trajectories can vary by as much as a factor of 6; however, they can quite easily be kept in the 1 million mile miss region. Since the comet is inclined by about 17 degrees, we can expect that the miss coefficients will be very sensitive.




Path of the Comet Rotated Into the Ecliptic



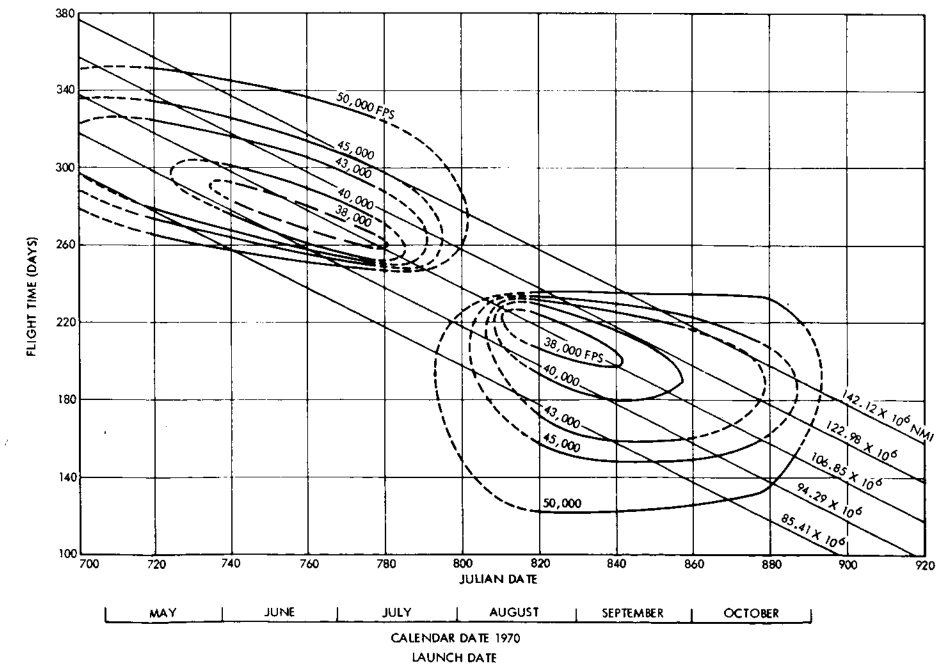

Miss Distance Resulting From Uncorrected Errors at Injection




Closing Velocity Contours

Legend:

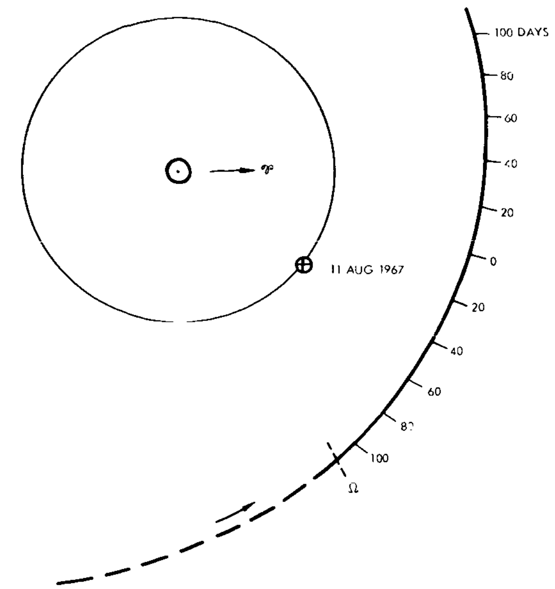
q = 1.385 AU
i = 17.2°
e = 0.611



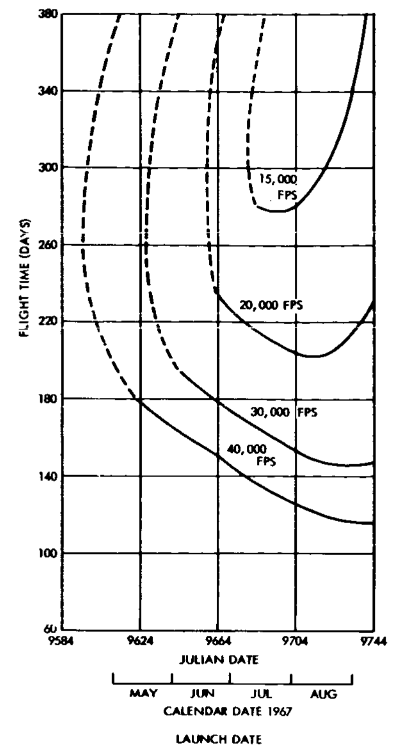

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

# REINMUTH (2)

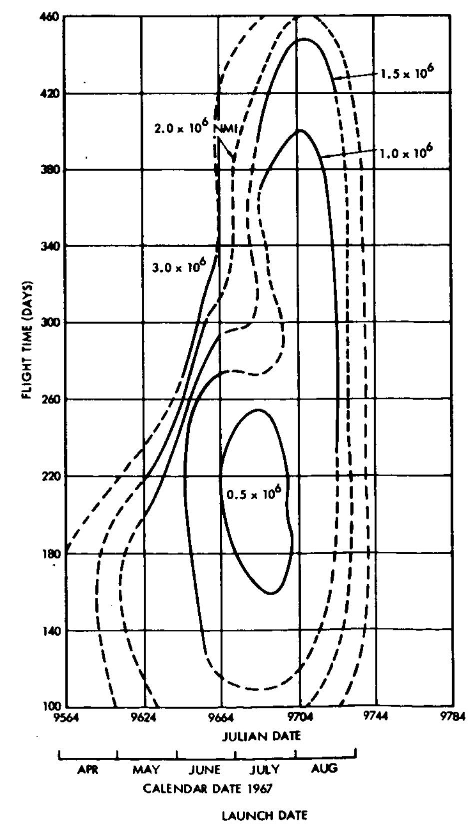
Reinmuth (2) makes a fair target in 1967 but is quite poor in 1974. Nevertheless, even in 1967 the minimum velocity trajectories are in the order of 46,000 fps with about 1 month of launch window. Since the transit trajectory can be quite asymptotic to the comet orbit, the injection velocity contours are extremely vertical and the flight time can be changed with the same velocity by as much as 200 days. This same effect is reflected in the closing velocities which are also quite vertical, and the same is again true for the miss. The closing velocity is very low in late July or August, especially with long flight times since the launch will be at the node and hence the intercept angle is small. Since Reinmuth (2) is 0.9 AU from the earth's orbit at perihelion, the transmission distance will be very long, at least 200 million miles.




Path of the Comet Rotated Into the Ecliptic



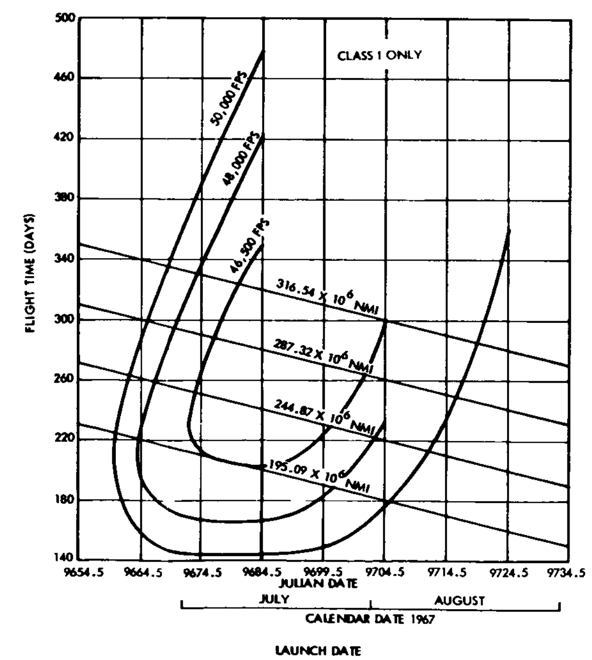

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

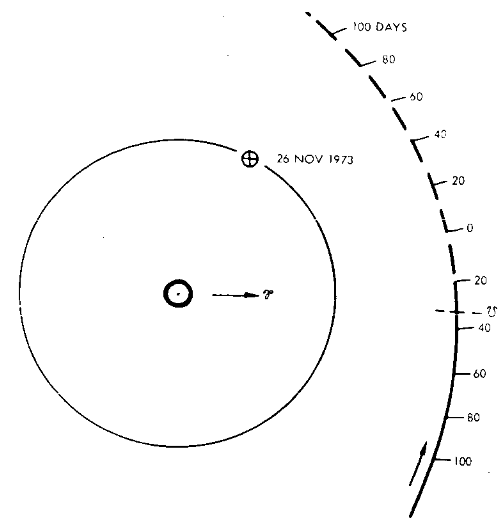
q = 1.933AU
i = 7.0°
e = 0.457



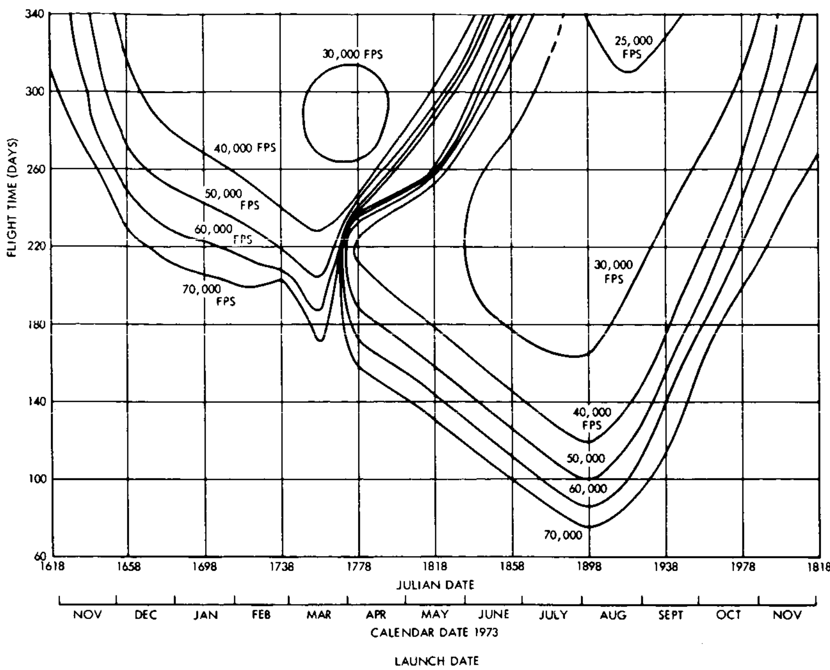

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

## BROOKS (2)

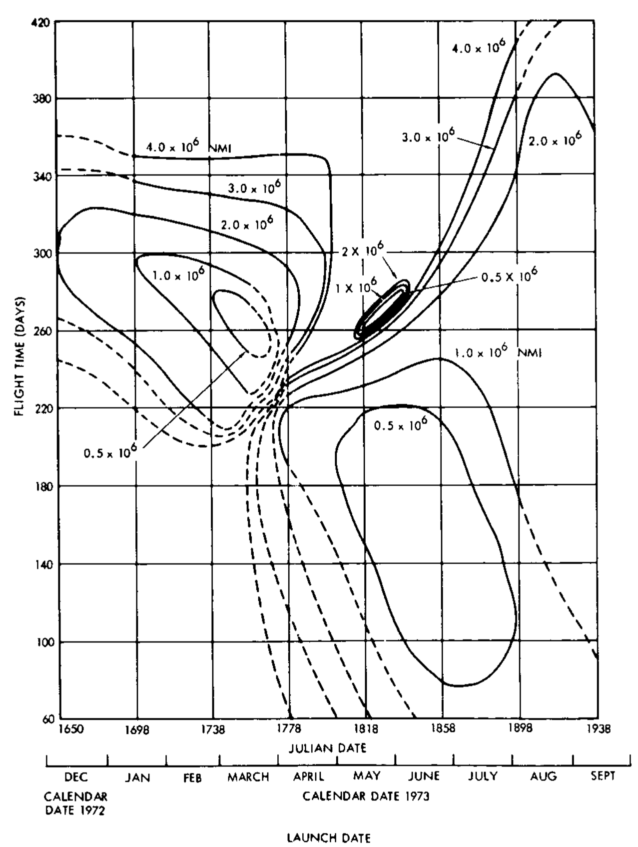
Brooks (2) is an excellent target in 1973 in terms of injection velocity; however, the flight times are a minimum of 160 days and a maximum of 220 days. The transmission distance of 120 million miles is also large. This distance is largely the result of the fact that the comet does not approach closer than 0.76 AU of the earth's orbit. Closing velocities for the low injection velocity launch period are all about 30,000 fps with little opportunity to change this velocity through trajectory selection. The miss distance can fluctuate considerably but is generally in the order of 500,000 miles.




Path of the Comet Rotated Into the Ecliptic



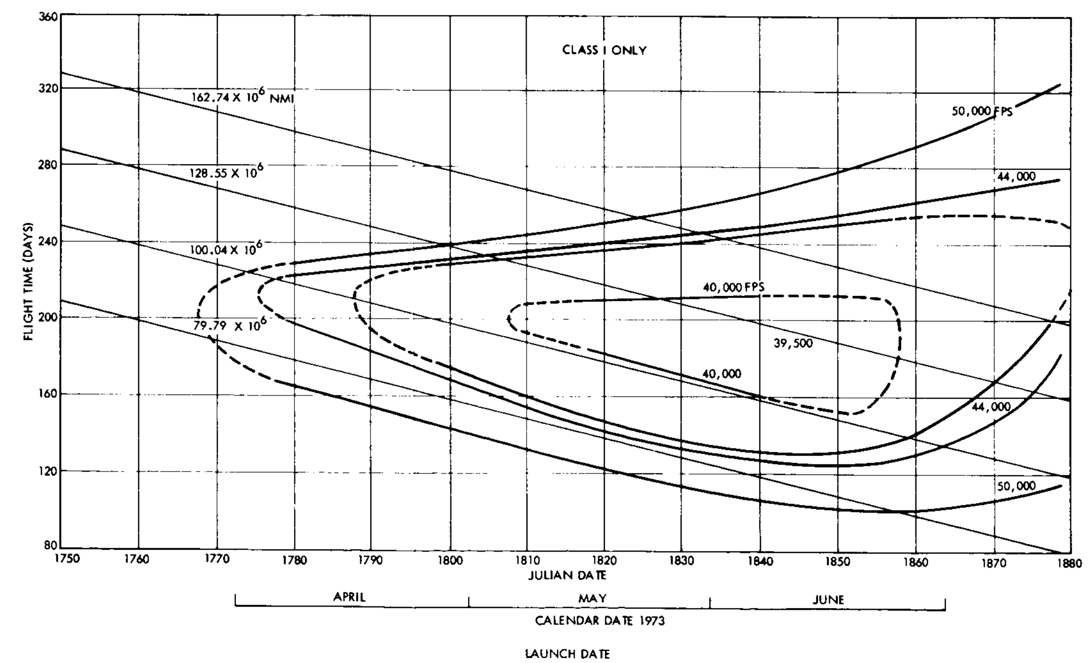

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

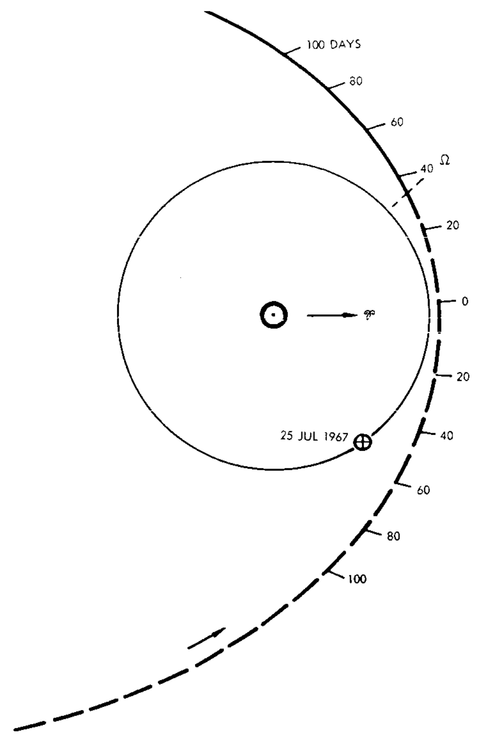
q = 1.763 AU
i = 5.6°
e = 0.505



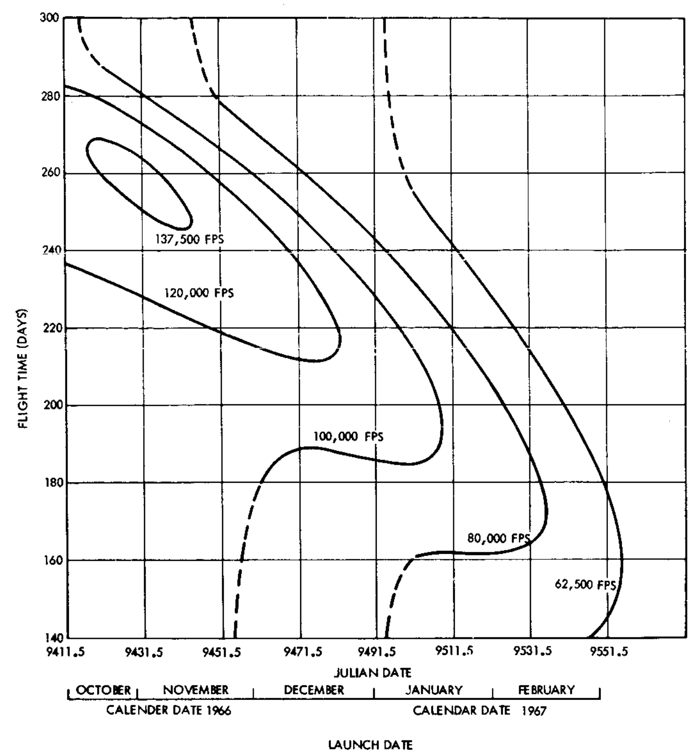

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

# FINLAY

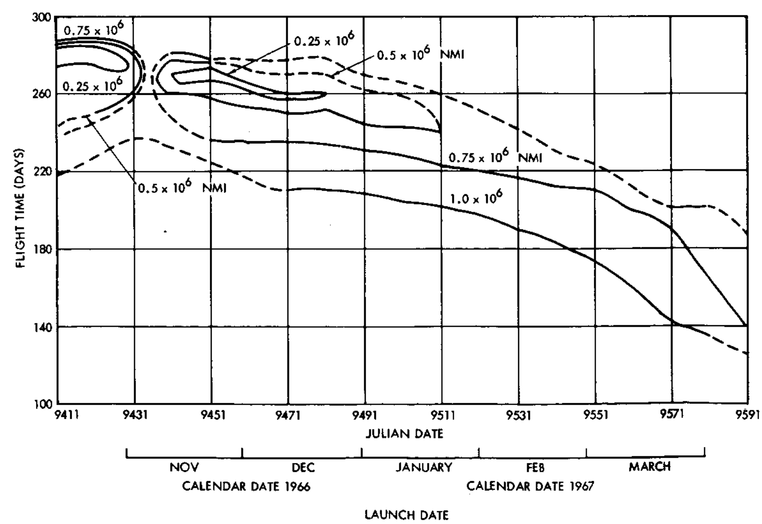
Finlay is fairly well located in both 1967 and 1974. In 1967, with injection velocities of 41,000 fps, there is a 2-1/2 month launch window and the flight time can be kept to 210 days. With 43,000 fps, flight time can be reduced to almost 180 days and the launch window can be almost 4 months long. The transmission distance at arrival is about 85 million miles which is satisfactory. Closing velocities are generally very high with a minimum of about 80,000 fps and as high as 137,000 fps near the minimum energy trajectory, in part caused by large intercept angles.




Path of the Comet Rotated
Into the Ecliptic



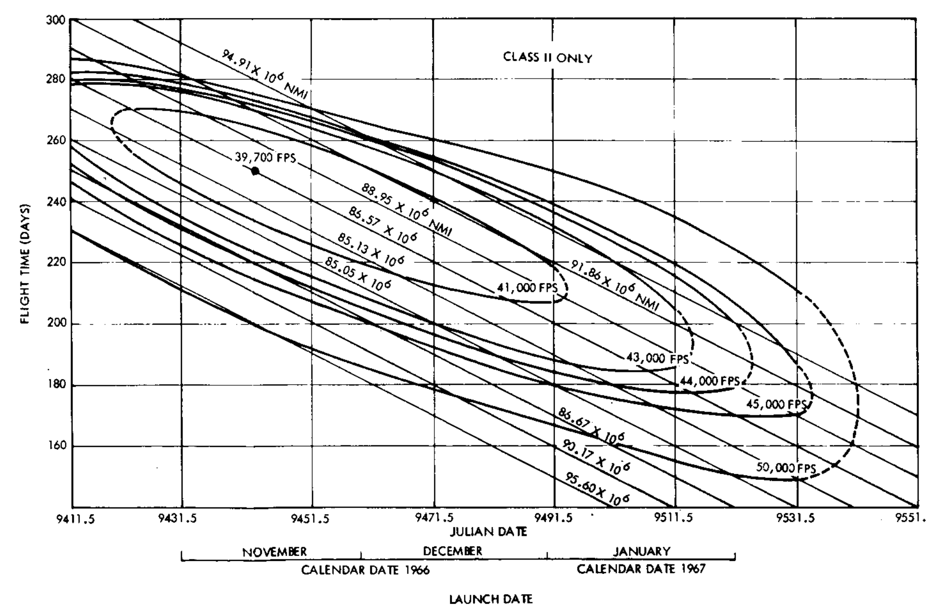

Closing Velocity Contours




Miss Distance Resulting From
Uncorrected Errors at Injection

Legend:

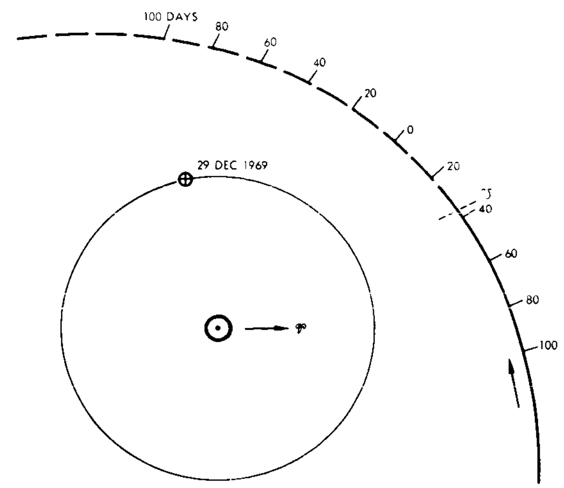
q = 1.077 AU
i = 3.6°
e = 0.703



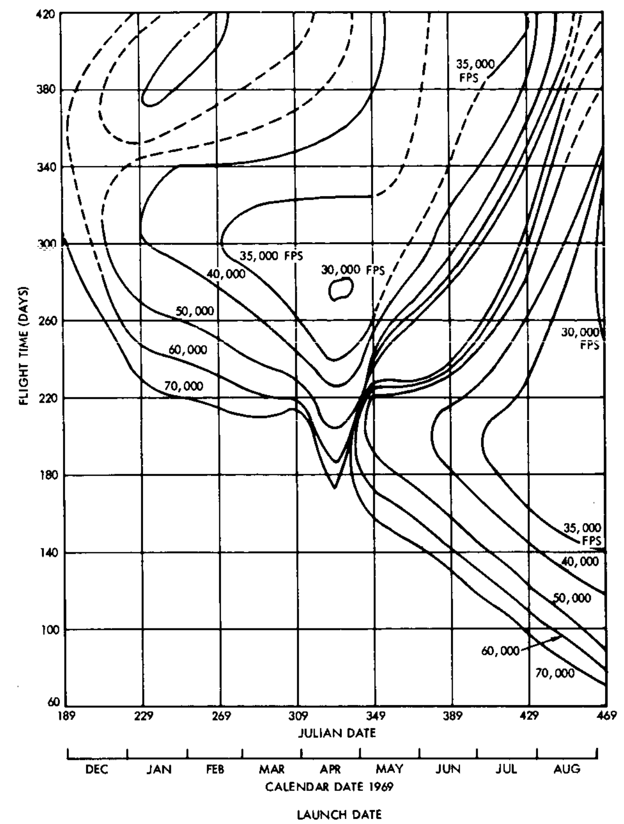

Injection Velocity Contours and
Transmission Distance at Arrival
(Injection Altitude: 177nmi)

# FAYE

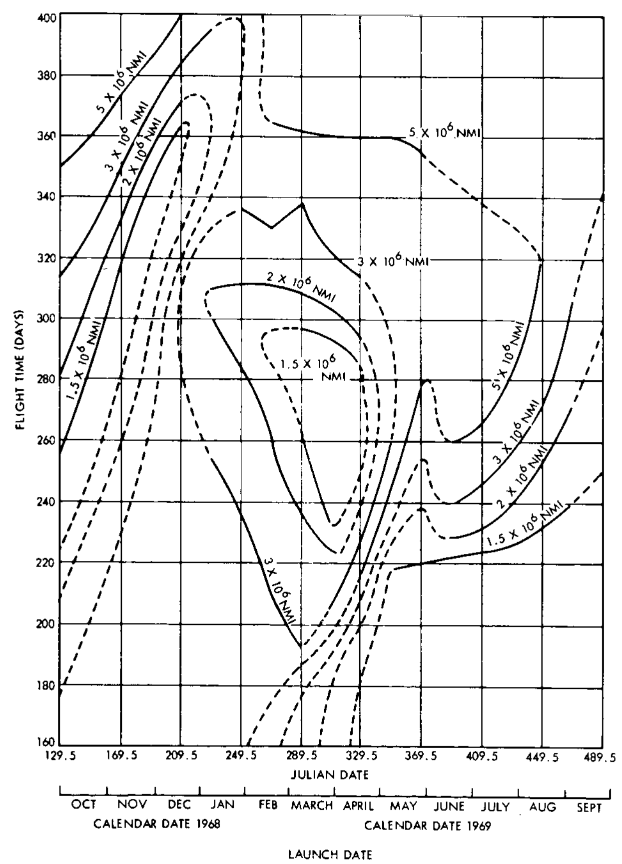
Faye will be a possible target in 1969 but a rather poor target in 1974. In 1969, with 40,000 fps, there is almost a two month launch window and flight times can be as low as 150 days. The transmission distance is in the order of 90 million miles which is not unreasonable. During a June or July launch, the closing velocities will be in the order of 40,000–70,000 fps. The miss can be less than 1.5 million nautical miles. Since the inclination is not great, miss coefficients will not be large.




Path of the Comet Rotated Into the Ecliptic



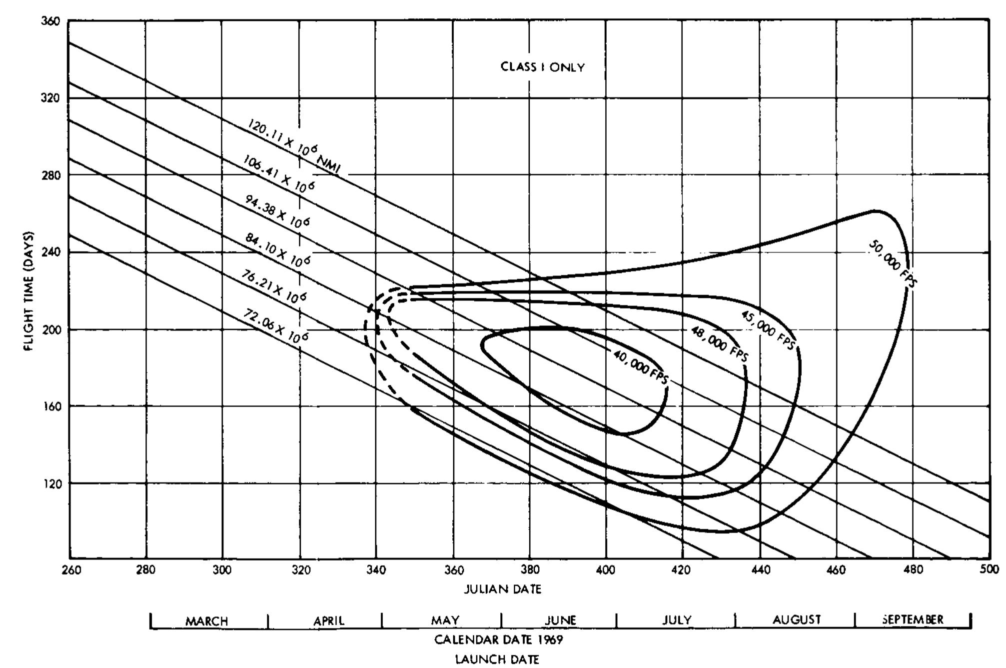

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

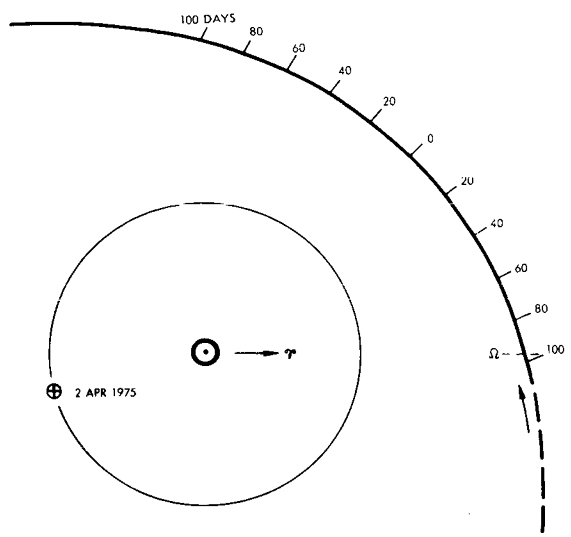
$q = 1.652$ AU
$i = 10.6^{\circ}$
$e = 0.565$



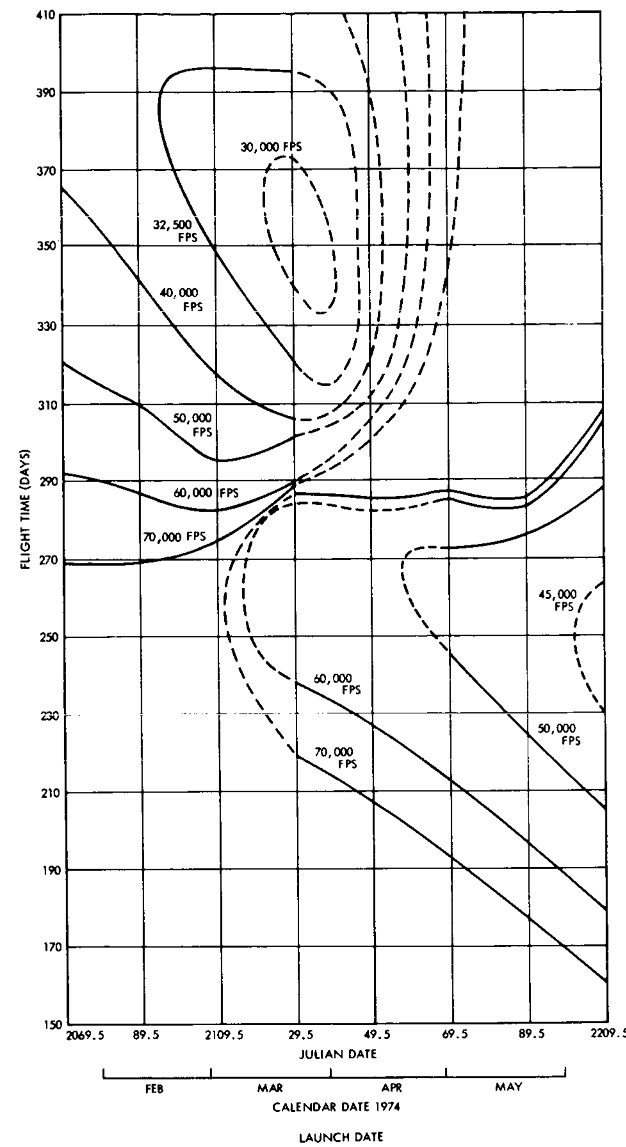

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

## AREND

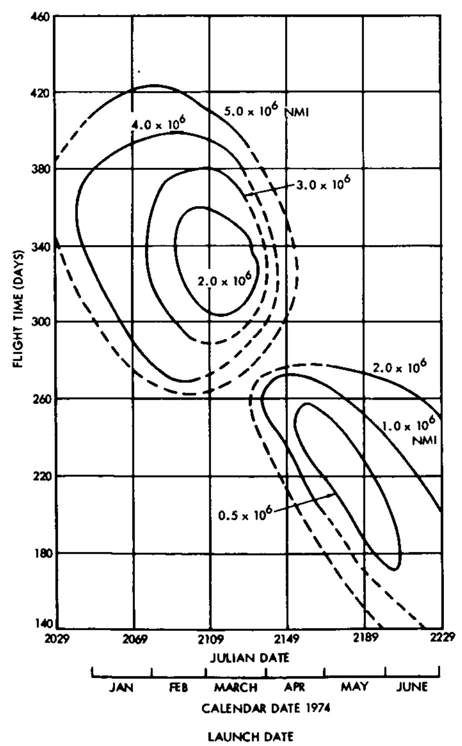
Arend is not a good target in either 1967 or 1975. For the 1975 trajectories, a minimum velocity of 40,000 fps is associated with the flight times in excess of 230 days. The launch window is about 2 months. Since Arend passes quite far from the earth's orbit, the transmission distances are about 190 million miles, which is excessive. The closing velocities in the region of interest are large, about 60,000 fps. For long flight times, the closing velocity can be as little as 30,000 fps for a March launch which allows the vehicle to fly in the plane of the comet's orbit. The uncorrected miss can be kept near 500,000 miles. In addition, Arend is inclined by 21.7 degrees which means that miss sensitivities will probably be very large.




Path of the Comet Rotated Into the Ecliptic



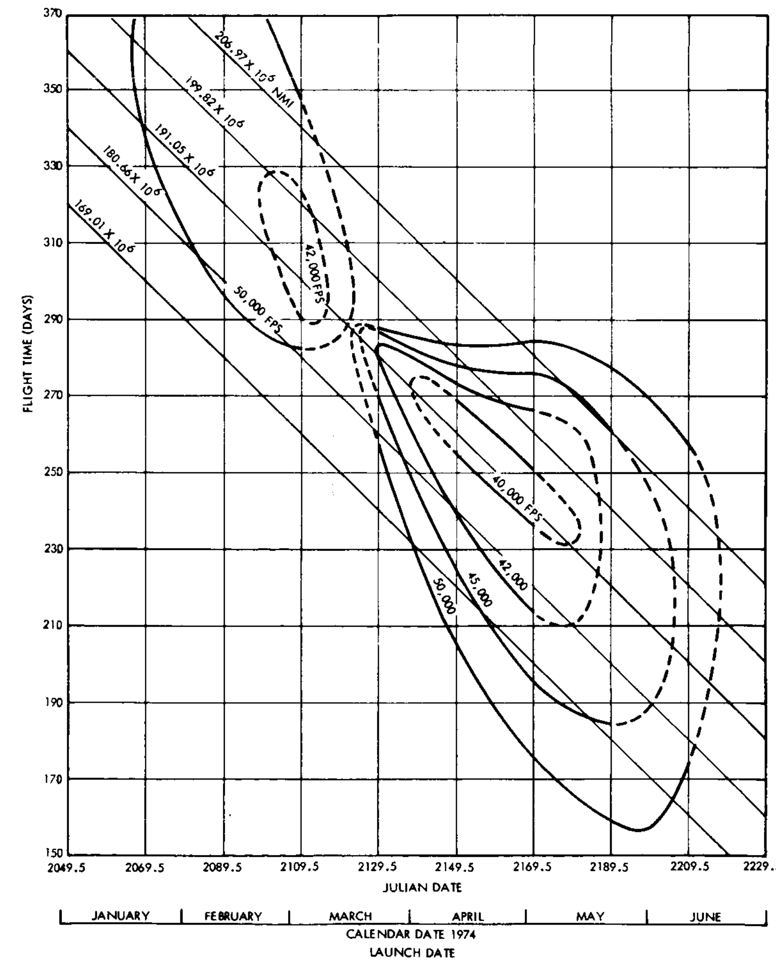

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

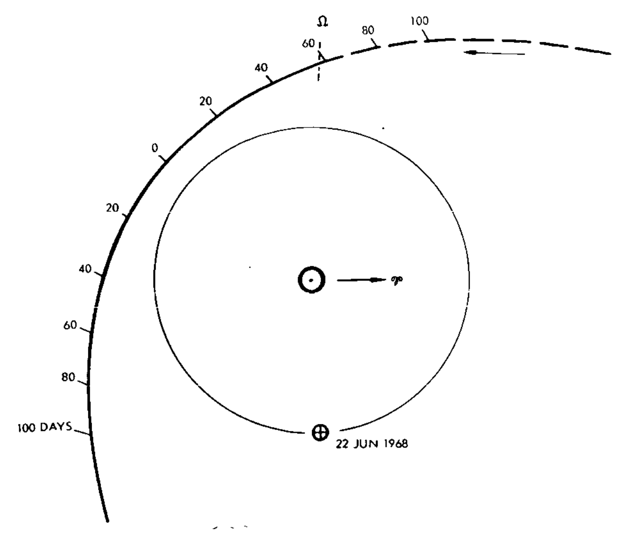
q = 1.832 AU
i = 21.7°
e = 0.534



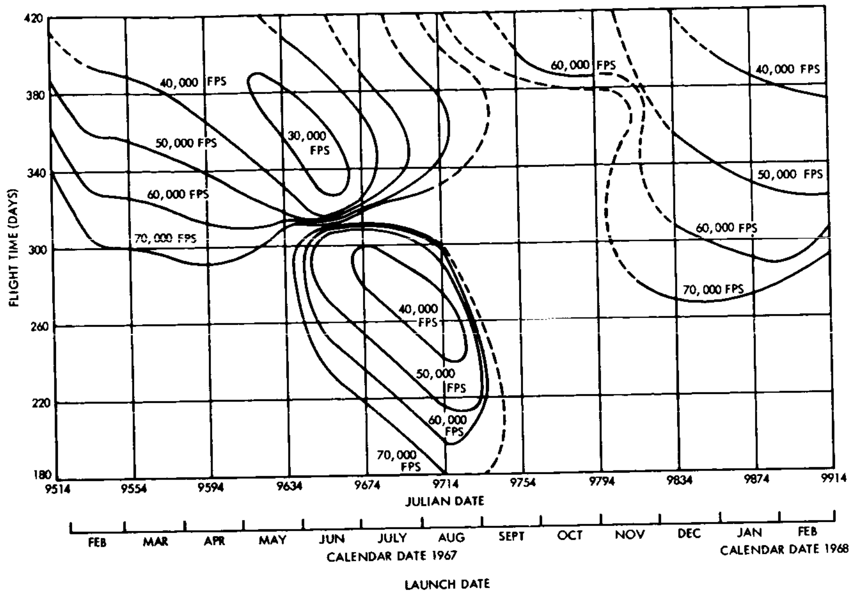

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

## SCHAUMASSE

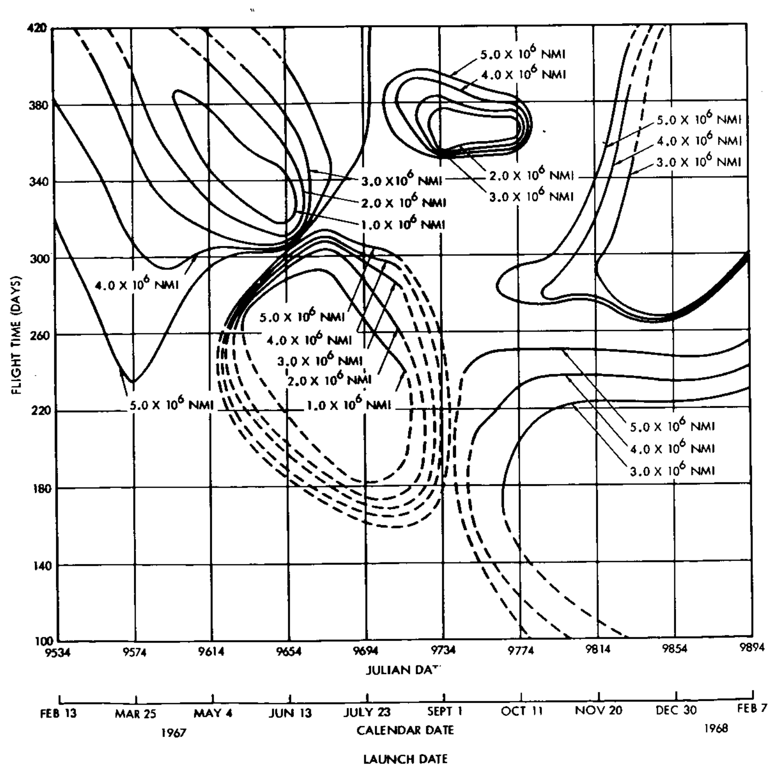
Schaumasse does not present a particularly good target in either 1968 or 1976. As can be seen, in 1968 the flight times are all very long, in the order of 320 to 420 days, even though the injection velocity is not large, 39,000 fps. For these flight times, the transmission distance is also very long, about 170 million miles. The closing velocity will be anywhere from 40,000 to 70,000 fps. In addition to the other difficulties presented by this comet, the misses for our assumed set of errors can be very large, between 1 to 4 million miles, which would present substantial midcourse requirements even though the miss coefficients might be very sensitive.




Path of the Comet Rotated Into the Ecliptic



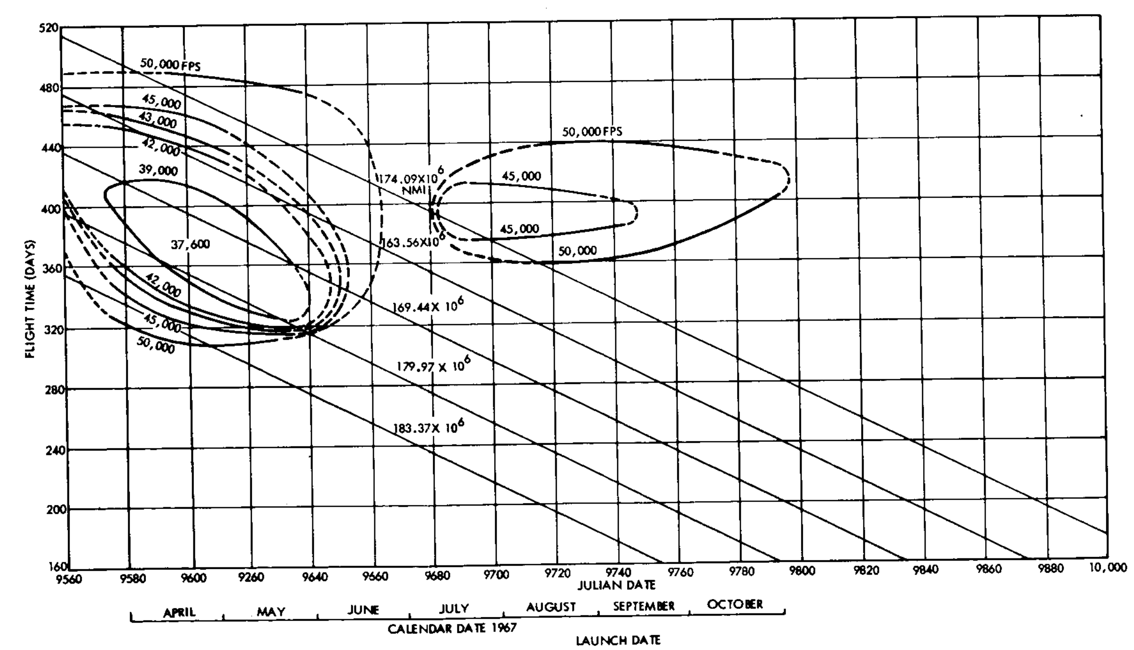

Closing Velocity Contours




Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

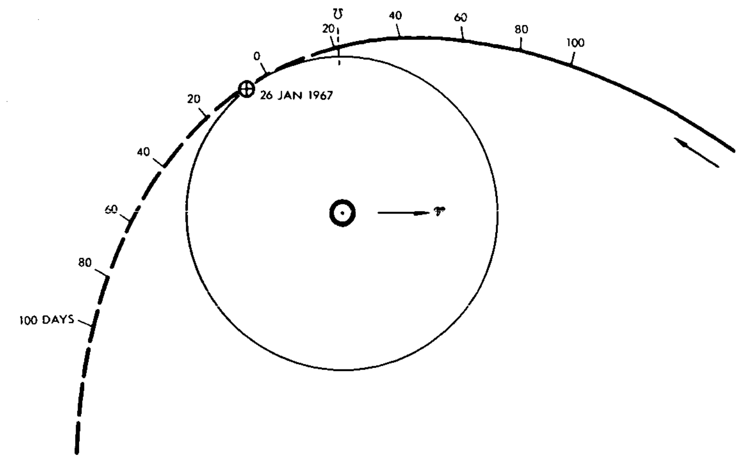
q = 1.196 AU
i = 12.0°
e = 0.705



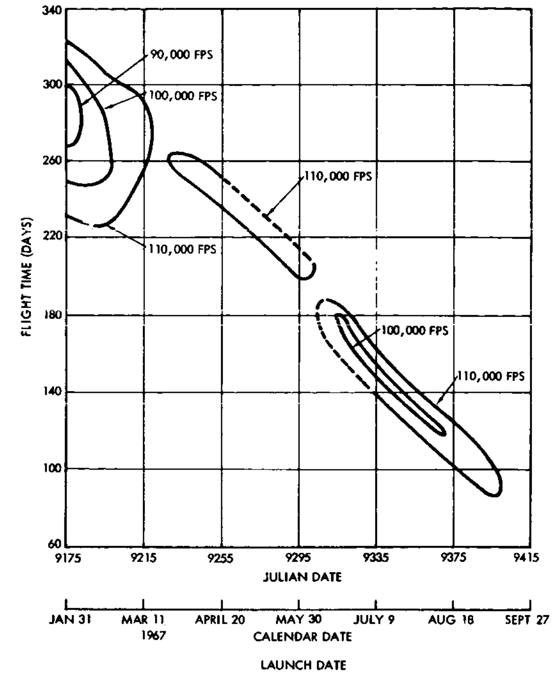

Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177 nmi)

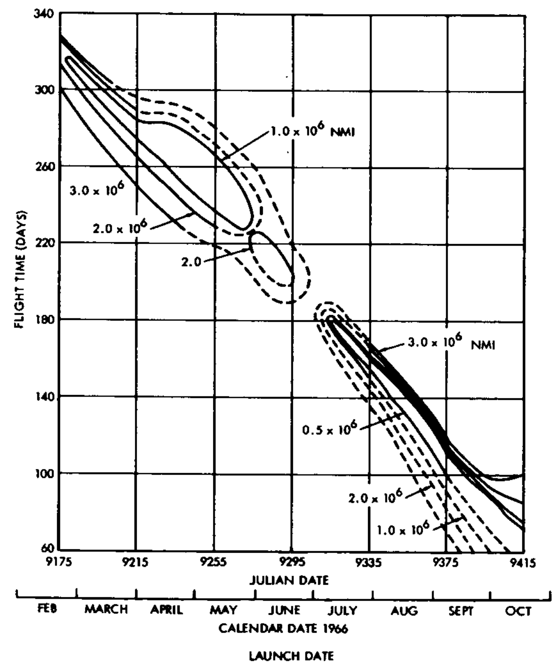
# TUTTLE

Tuttle is a possible candidate during 1967 and the injection velocities are quite nominal. Moreover, the flight time from an injection velocity of 40,000 fps can be as small as 75 days. The launch window is in the order of 4 months. However, Tuttle is inclined by 54.7 degrees and is quite eccentric, 0.821. The sharp inclination has the effect of making the transmission distance a minimum of 20 million miles even though perihelion is almost at the earth's orbit. In addition, as shown on the closing velocity figure, the minimum closing velocities are in the order of 100,000 fps. Again, although the miss distances can be kept fairly small in certain areas, the miss coefficients will be extremely large.




Path of the Comet Rotated Into the Ecliptic

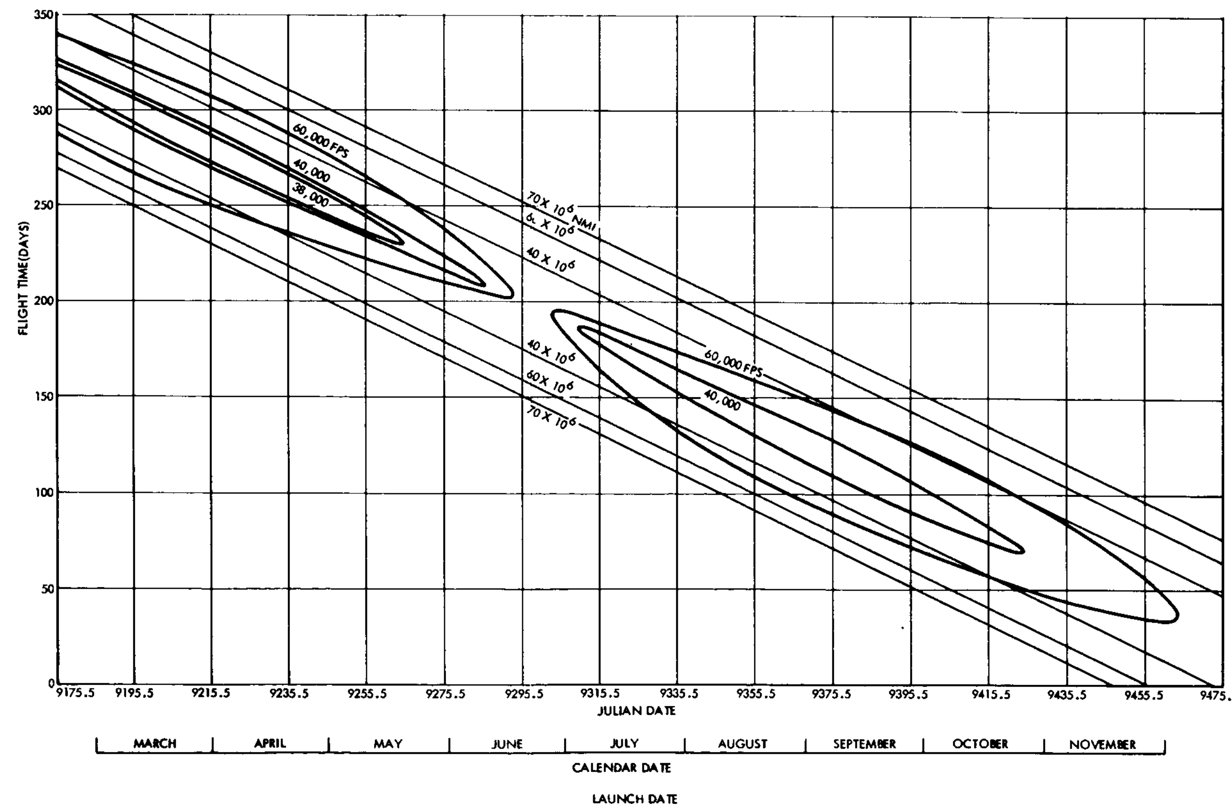



Miss Distance Resulting From Uncorrected Errors at Injection

Legend:

q = 1.022 AU
i = 54.7°
e = 0.821




Injection Velocity Contours and Transmission Distance at Arrival (Injection Altitude: 177nmi)

# V. A POSSIBLE COMET MISSION

STL has analyzed a specific mission to the comet Encke. Encke was selected because the injection velocities are reasonable and because it is the most well known of all the comets and, hence, its orbit has been determined accurately. Although the discussion here is merely intended to indicate the feasibility of such a mission, STL's extensive work in related fields, and especially in the study of interplanetary probes, indicates that the mission could be carried out in the very near future, if desired.

The most effective means for achieving long term stabilization with minimum weight is with a spinning spacecraft. The simplest way of getting antenna gain with a spinning spacecraft is by using a narrowed $360^{\circ}$ antenna beamwidth which is oriented so that the earth is in the beam. Again, the simplest way of maintaining thermal control and maximizing power from the sun with the spinning spacecraft is to place the spacecraft in space such that a specific area of the spacecraft sees the sun continuously. The method presented here permits both of these objectives to be achieved.

The comet intercept spacecraft is designed to maintain an essentially constant attitude with respect to the sun and the earth. The constant attitude with respect to the sun simplifies the thermal control and power supply system, and the constant attitude with respect to the earth allows 13 db of antenna gain which greatly reduces the transmission power requirements. Although this concept was originally proposed for use with spacecraft which can be placed in the plane of the ecliptic, it can also be used for missions such as this comet mission.

The spacecraft is injected into its trajectory to the comet. After separation from the third stage, the spinning spacecraft is then reoriented in two steps (see Figure 5-1). The first step aligns the spacecraft perpendicular to a line from the sun. This step is performed by using simple sun sensors which get signals from the sun and cause a gas jet to fire a small portion of each spacecraft revolution, which torques the spacecraft. Two sets of sun sensors are used for signals from the sun and delay circuitry insures the correct firing time during each revolution. When the signal from the sun has been nulled at each sensor, the spacecraft is then perpendicular to

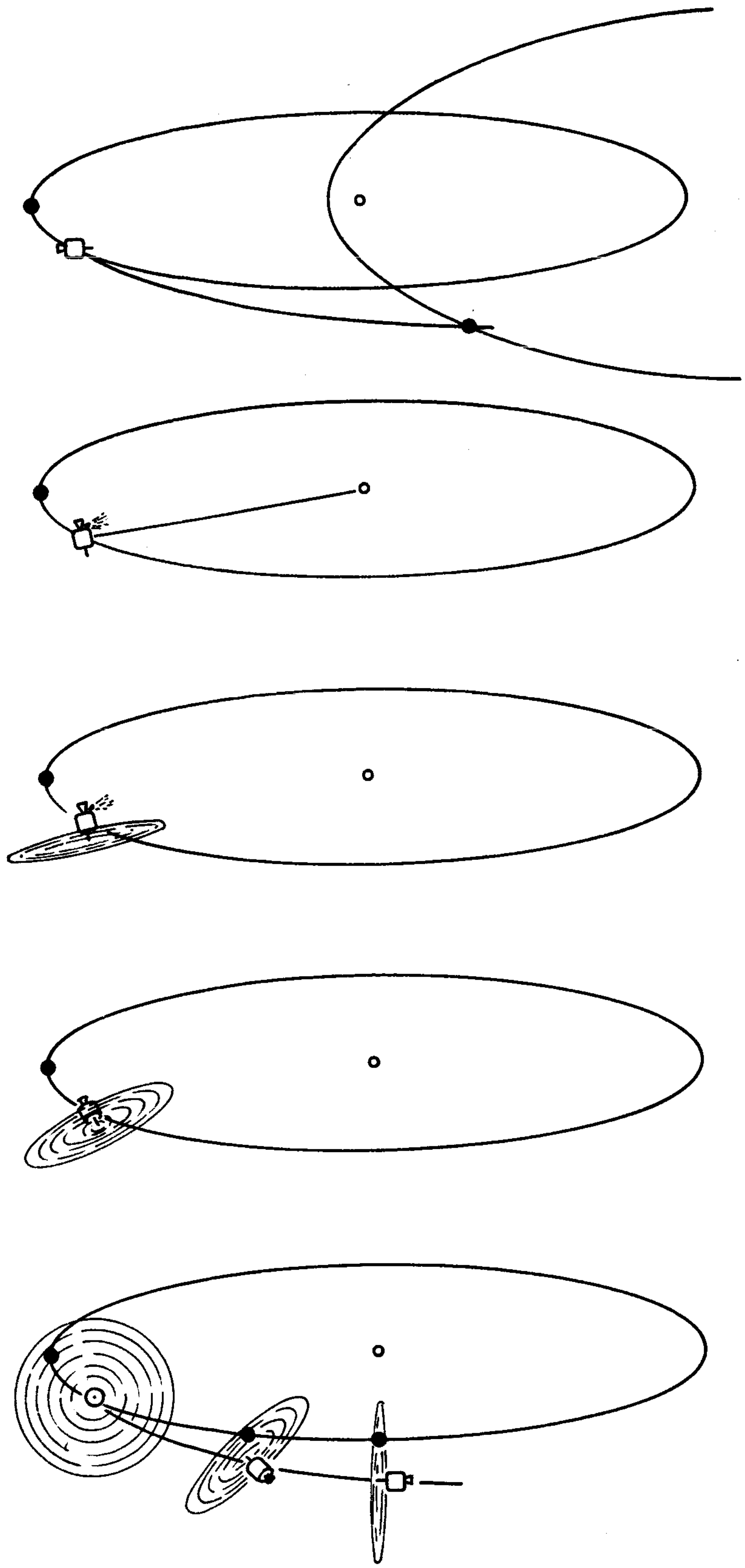


Figure 5-1. Reorientation Maneuvers for Mission to Encke, 1964

a radial line from the sun. During step 2 the jet is again fired with a different delay causing the spin axis to rotate in the plane perpendicular to the sun line. This rotation is continued until the fan beam of the antenna is centered on the earth. The centering is determined on the ground from the magnitude of the signal received. In general, since transfer trajectories may be substantially out of the plane of the ecliptic, the angle between the spacecraft's plane and the earth line changes. Therefore, step 2 will need to be repeated from time to time. For the Encke trajectory proposed, the maximum total precession will be less than $90^{\circ}$ so that gas consumption will be small. Of course, for this trajectory, it would be possible to use simply a parabola rather than a fan beam and keep that parabola going toward the earth after the spacecraft is in its trajectory without affecting power or thermal control. However, to simplify the spacecraft to make it applicable for all comet missions, a fan-beam antenna is used.

The booster assumed is an Atlas-Agena D with a solid propellant third stage whose performance is shown in Figure 5-2.*

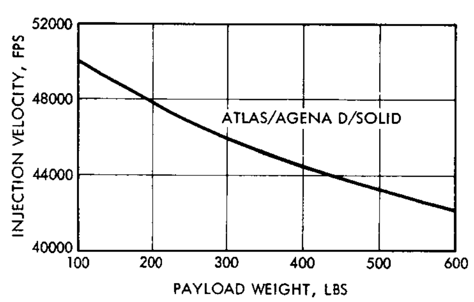



Figure 5-2. Payload Performance of Atlas/Agena/Solid Propellant Third Stage Vehicle

As can be seen in this curve, the vehicle can inject 600 pounds to 42,000 fps, 500 pounds to 43,200 fps, and 450 pounds to about 44,000 fps. We can compare this with the injection velocity contours for comet Encke shown in Section IV to determine what our capabilities are. The region of

*The performance of the vehicle shown here is taken from SP RFP A-6842: NASA-Ames Research Center.

interest is clearly in the 42,000 fps contours for the short flight times of 100-150 days. As we can see, this gives us a launch window from about February 18 to April 18. Such a launch window is more than adequate since, as pointed out earlier, we can expect to sight the comet more than 200 days before launch time. A 6-month interval is clearly more than satisfactory for determining Encke's orbit to the accuracy required and allows a considerable amount of time for any unexpected problems arising in the sighting, in the orbit determination, or in the actual launch preparation.

The proposed comet probe is shown in Figure 5-3. It is a simple spin-stabilized spacecraft evolved from STL's Explorer VI and Pioneer V spacecraft and is essentially a modification of STL's recent Pioneer spacecraft developed in a study for NASA, Ames Research Center. The spacecraft is shown mounted on the ABL 258 solid rocket motor. The ABL 258 is mounted on a standard spin table (the one shown is the Douglas Thor-Delta spin table) which is attached to the Agena. Eight small solid rocket motors are mounted to the spin table and, when ignited, spin the third stage up to 150 rpm to control the thrust alignment of the third stage. A conical adapter supports the ABL 258 with a V-clamp for separation. The separation force is provided by three matched and oriented springs located inside the nozzle cone which minimizes tip-off problems. An exit clearance of $15^{\circ}$ from the interstage is provided for the nozzle.

The spacecraft is supported on the ABL 258 by a cylindrical interstage attached to the upper end of the ABL 258. The separation force between the third stage and the spacecraft is also provided by three matched, oriented springs mounted as close together as possible, again to minimize tip-off. The separation force is exerted through a cylindrical section surrounding the nozzle which is also used as a heat shield for the nozzle during flight. Again, a $15^{\circ}$ exit clearance is provided for the spacecraft nozzle. A standard yo ball spin mechanism will be used on the third stage to insure separation.

The spacecraft itself consists essentially of a cylindrical outer shell upon which the solar cells are mounted, a central equipment mounting platform which is attached to the shell and to a hydrazine tank in the center, and a cylindrical support structure around the engine and attached to the

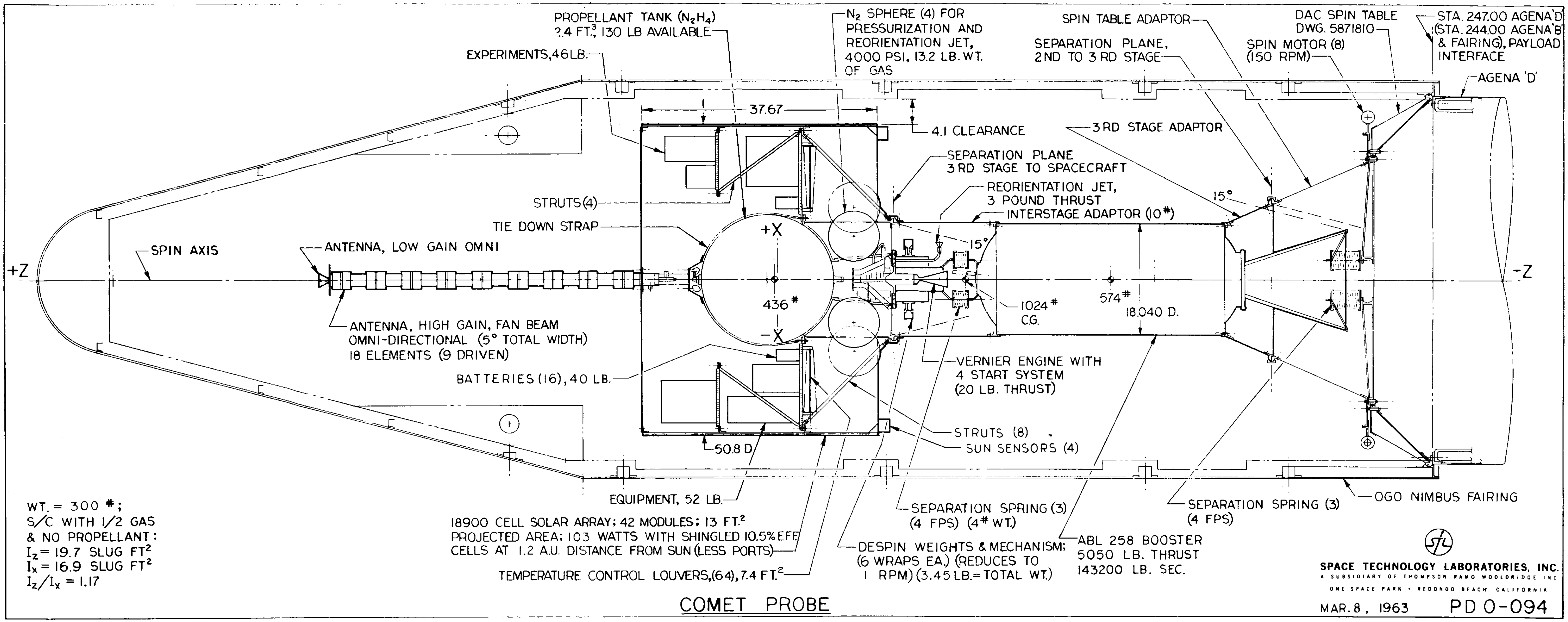



Figure 5-3. Drawing of Proposed Comet Probe

inner edge of the central platform and the hydrazine tank mounting structure. An additional shelf area is provided above the central equipment mounting platform for additional equipment. An 18-element Franklin array antenna is mounted at the top of the hydrazine tank and supported by the metal cover of the spacecraft. At the top of the high-gain antenna, an omnidirectional antenna is also mounted. Beneath the main platform a set of bimetallically actuated thermal control louvers are mounted to permit excess heat to be radiated into the spacecraft. During low power portions of the duty cycle, the louvers close automatically to maintain the internal environment at a satisfactory temperature.

The hydrazine monopropellant system is used for midcourse guidance corrections and terminal corrections. The nozzle of this system is mounted at the bottom of the spacecraft along with the high-pressure nitrogen gas bottles which carry 13.2 pounds of 4,000-psi nitrogen. This gas is not only used for propellant tank pressurization but is also used for the reorientation system which torques the spinning spacecraft into any desired attitude. The nitrogen engine is a 4-start, 20-pound thrust unit and is sized to supply 2,500 fps correction capability. The reorientation system, with a 3-pound thrust nozzle located near the propulsion system nozzle, can turn the spacecraft through a minimum of $1440^{\circ}$. A yo ball de-spin mechanism is mounted around the outside of the nozzle area and is used in the vicinity of the comet to reduce the spacecraft spin rate to 1 rpm in order to take the TV picture of the comet.

The main equipment shelf carries the high-power equipment and the batteries since they require the most careful thermal control. The upper shelf area, if required, will carry the low-power items such as experiments, etc. The entire compartment, including the top cover, is thermally insulated to insure the proper internal temperature. Forty pounds of batteries are mounted in a ring on the main equipment compartment. The solar array mounted on the outside of the shelf consists of 32 modules, each 37.67 x 3.671 in., arranged side by side around the cylindrical surface. The array has 18,900 cells which produce 142 watts at 1 AU from the sun and 63 watts at 1.5 AU from the sun. The spin stabilization of the spacecraft is assured since the ratio of roll-to-pitch moment of inertia is a minimum value of 1.2. The spacecraft and third stage are surrounded by the OGO nimbus fairing during the aerodynamic phase of the launch.

## A. MISSION PROFILE

The spacecraft will be launched from Cape Canaveral by the Atlas-Agena ABL 258 booster vehicle and placed into a 100 nmi coasting orbit where it coasts until the proper time for injection into the trajectory which will take it to the comet intercept. At the end of the orbital coast period, the Agena will restart, burn, and shut down; the third stage and spacecraft will be spun up by the spin table, and the third stage will be ignited. At the end of the third stage burning, the spacecraft will be separated and coast on its way to intercept. After separation, a yo ball de-spin mechanism will pull the third stage away to prevent it from impacting the spacecraft should there by any residual chuffing.

Spacecraft commands during powered flight will be handled internally. Soon after separation the spacecraft will begin the first step in its reorientation maneuver to insure good thermal control and adequate power supply. The spacecraft will be tracked by the DSIF station at Johannesberg and possibly at Woomera using the omnidirectional antenna for both reception and transmission. Tracking will continue for 5-7 days, at which time the errors accumulated at burnout will be carefully evaluated and the direction and magnitude of the midcourse correction will be determined. At this point the second step in the reorientation maneuver will be performed to determine the attitude of the spacecraft. Once the attitude of the spacecraft is determined, which should be good to $\pm 1^{\circ}$, the spacecraft will then be torqued in an open-loop mode using an on-board counter which is commanded from the ground. The spacecraft will then be torqued into an arbitrary direction which will place the spacecraft spin axis perpendicular to the critical plane. At this time, the spacecraft will be commanded to fire the midcourse propulsion engine for proper duration to remove the errors at injection. The uncorrected miss at intercept for the boost configuration assumed here will be in the order of 100,000 nmi, $3\sigma$. After the midcourse correction, the error ellipse at intercept should be reduced to the order of 500 n mi. Upon completion of the midcourse correction, the spacecraft will go through its reorientation maneuver and come back to the nominal attitude perpendicular to the sun and with the fan-beam antenna on the earth.

The actual trajectory studied is shown in Figures 5-4, a, b, and c, and 5-5 for all three axes. As can be seen from these figures, the spacecraft is launched from the earth with a beta somewhat less than $90^{\circ}$ and an inclination of about $12^{\circ}$, which is almost the exact inclination of the comet orbit itself. The spacecraft first moves outside the earth's orbit slightly, but at the time of impact it has recrossed the earth's orbit and is about 1 AU from the sun and about 20 million nmi from the earth, largely beneath the earth. This trajectory is an excellent one from all practical points of view since injection velocities are reasonable and only used to take account of the inclination of the comet; the flight time is short; the transmission distance at intercept is excellent; and the solar power, as well as thermal control, are considerably simplified since the spacecraft is only about 1 AU from the sun. At intercept, since the spacecraft is south of the earth, the ground antennas at Woomera and Goldstone can be used, but the antenna at Goldstone will not be useful.

As described in Section IV, the combination of spacecraft injection accuracy and comet orbit determination will result in injection errors in the order of 500,000 miles. The first midcourse correction should reduce the overall error to less than 10,000 miles. However, sufficient propellant is carried in the spacecraft to allow a correction near the comet of 2500 fps. If this correction is made 10 days before intercept, the spacecraft can be moved 300,000 miles. This capability can therefore be used to refine the spacecraft trajectory using about 100 days of both comet and spacecraft tracking data. However, since it is not expected that a correction of this magnitude will be necessary, this propulsion capability can also be used to change the velocity of the spacecraft with respect to the comet during intercept if desired, either to increase the closing velocity or to decrease it.

At intercept, since an important experiment is to take a TV picture of the nucleus, it will be necessary to slow down the spin rate of the spacecraft to give adequate resolution. The method proposed is to use yo ball de-spin mechanisms, attached around the propulsion nozzle, which have been sized to slow down the spacecraft to 1 rpm. At this speed the resolution of the spacecraft speed will be just adequate. However, an inertial wheel system has also been considered. Such a wheel, which

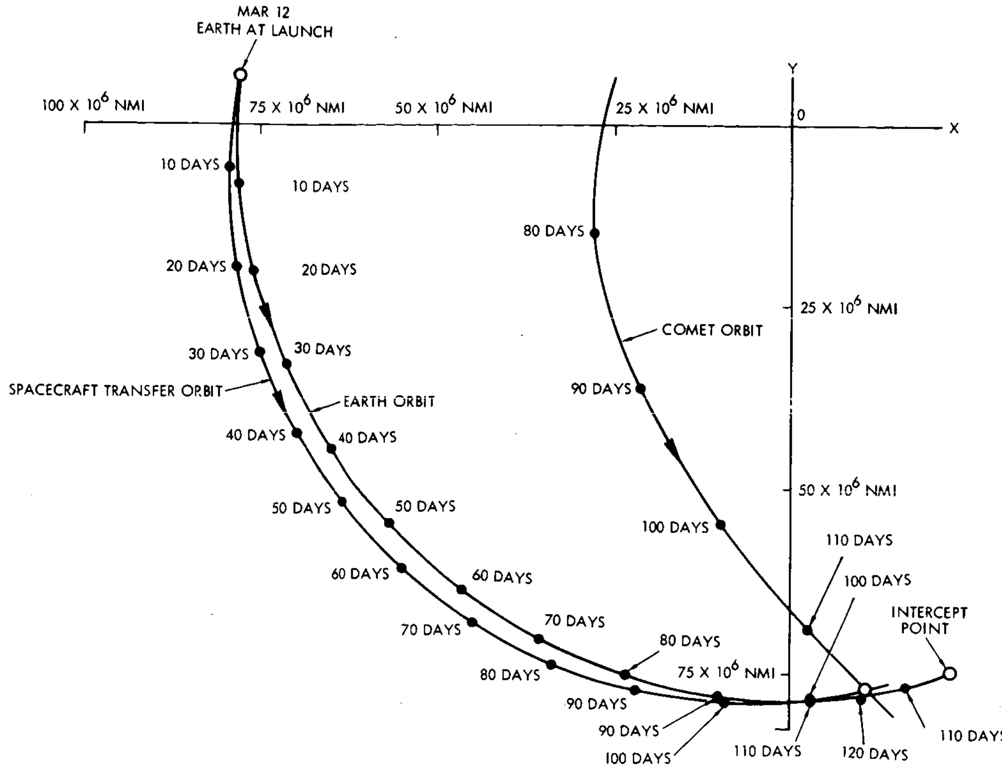



Figure 5-4a. Earth, Comet, and Transfer Orbits in the X-Y Plane of the Ecliptic

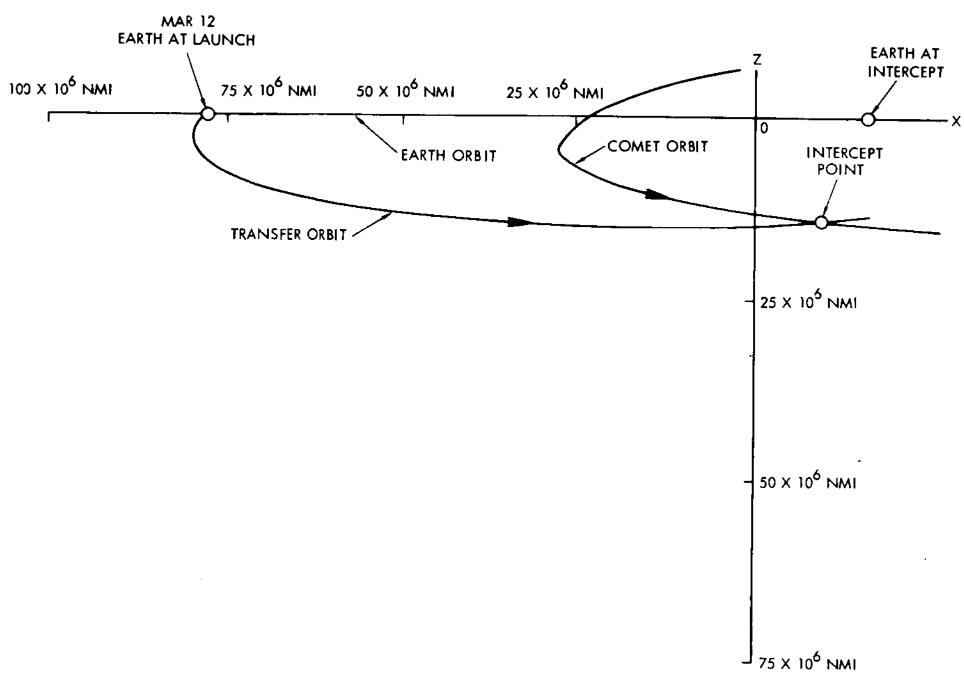



Figure 5-4b. Earth, Comet, and Transfer Orbits in the X-Z Plane of the Ecliptic

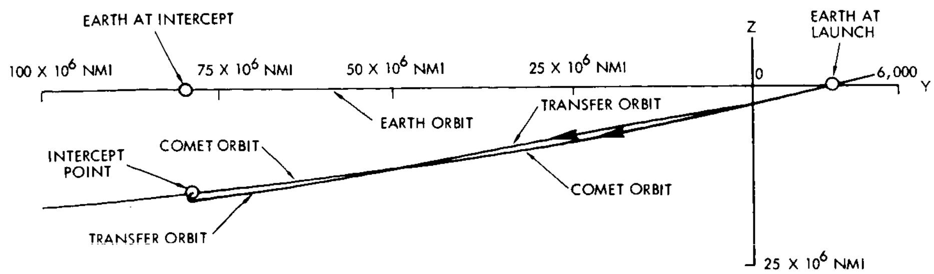



Figure 5-4c . Earth, Comet, and Transfer Orbits in the Y-Z Plane of the Ecliptic

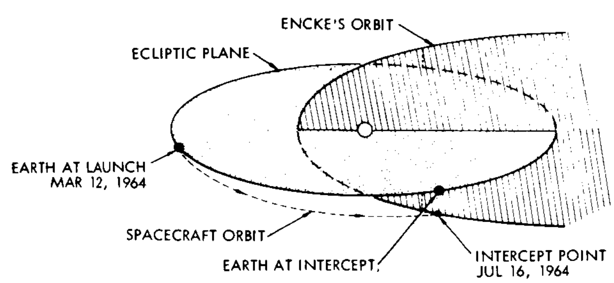



Figure 5-5. Three-Dimensional Composite of Earth, Comet, and Transfer Orbits

would need to weigh about 10 pounds and revolve at about 6,000 rpm, could be used to absorb the angular momentum of the spacecraft and slow down its spin rate almost to zero. In addition, when the wheel is turned off, the energy will go back into the spacecraft and bring it up to its initial spin rate, thereby insuring as long a life of the spacecraft as the electronic components will allow. Thus, after intercept the spacecraft can continue into interplanetary space making additional useful measurements of the environment it encounters.

## B. SPACECRAFT

### 1. Structure

The comet spacecraft (Figure 5-3) is a spin-stabilized vehicle which has evolved from STL experience on Explorer VI and Pioneer V. The structural concept directly and logically satisfies the major design criteria of providing spinning stability and the appropriate strength and rigidity to withstand the steady state and dynamic loads of the boost phase environment.

Spin stabilization is achieved by having a larger moment of inertia about the spin axis than any other spacecraft axis. This ratio is increased by mounting experiments and subsystem equipment near the periphery of the spacecraft on two ring-shaped equipment shelves. The cylindrical shell which supports the solar modules is fastened to the rim of the platform.

The basic structural load path extends from the attachment to the ABL 258 engine through a short adapter to a series of structures which support the equipment shelf. The central tank is supported through a continuation of the adapter. The platform carries the load imposed by the weight of the outer shell and the solar array. The inside of the louver platform is attached to the support structure around the central spherical hydrazine tank. The communications antenna mast is rooted to the hydrazine tank. Sideloads transmitted by the mast are taken out by the upper cover, which is removable for packaging accessibility.

The integrated platform hydrazine tank, cylindrical shell and cover provide a structure having inherently large torsional and lateral rigidity.

The direct load paths minimize structural weight. In this way, the STL structural design for Pioneer achieves ample structural strength and stiffness within the constraints of volume, solar-cell area, antenna length, dynamic responses, thermal environment, and weight. The primary structure of the comet spacecraft is designed for the primary loads during boost.

The interstage is a truncated conical shell fabricated from a ZK60A magnesium roll-ring forging. It serves to transfer all spacecraft loads from the equipment platform to the ABL 258 adapter. The interstage is attached to the ABL 258 adapter by a V-clamp band which is preloaded in hoop tension upon installation. The mating flanges of the interstage and the adapter each slope 45 degrees. The hoop tension load in the band supplies a wedging force which maintains a compressive load at the separation plane and the capability to carry boost-phase loads through the mating flanges. The spacecraft is separated by releasing the V-clamp band by means of an ordnance device which allows the compressed separation springs to impart a relative velocity between the spacecraft and the third stage. The V-clamp band is restrained from damaging contact with the spacecraft by means of restraining cables and structural shielding. Aluminum sandwich-center support platforms are used because they make it easy to locate equipment and also provide a flat, rigid, mounting surface for efficient thermal transfer of equipment heat.

The magnesium alloy cylindrical shell provides a mounting base for the solar-cell substrates. The shell is ring-stiffened at the base. The shell, together with beaded aluminim cover and the intermediate equipment platform, forms a rigid cylindrical box. The solar array consists of solar cells mounted on 25 beryllium alloy substrates. Each substrate is 32.56 inches long and 3.71 inches wide.

Beryllium is chosen because of its high modulus of elasticity and low density. The substrates are stiffened by integral longitudinal flanges and and are attached to the spacecraft shell by means of six threaded studs. The substrates carry only their own inertial loads and those of the attached solar cells.

To stabilize the vehicle during third-stage operation, the spacecraft and ABL 258 will be spun up on the Thor-Delta spin table prior to second- and third-stage separation. The angular velocity will be in the range of 150 rpm. This spin rate is high enough to provide sufficient stability during powered flight, and low enough so that the angular momentum needed to perform the reorientation maneuver is not excessive. The planned spin rate does not impose excessive structural loads on either the probe or the third stage.

On the basis of Explorer VI experience, the attitude tip-off at separation of spacecraft from third stage will be quite small, so that the spacecraft attitude error will also be about 3 degrees. Such errors are compatible with the mission requirements on third-stage velocity direction and on initial spacecraft attitude. The spacecraft will be separated from the burned-out third stage by means of the Douglas separation springs (Figure 5-3), imparting a differential velocity of about 6 ft/sec. STL has used similar spring separation successfully on Pioneer V and Explorer VI. To insure that the third-stage case does not catch up and bump the spacecraft, separation of the spacecraft from the burned-out third stage will occur about 2 minutes after third-stage burnout, and be followed 2 seconds later by the deployment of a yo-type tumble device. The tumble device, proven on several Thor-Delta launches, consists of a weight attached to the end of a wire wound around the upper end of the third stage. The yo reduces the spin of the third stage to zero and changes its thrust direction drastically, eliminating the danger of bumping. The orientation maneuver, consisting of a series of step changes in spin-axis direction produced by timed impulses from gas jets, imparts a conical free precession or wobble. A wobble damper, consisting of a small angular tube partially filled with mercury mounted concentric with the spin axis of the probe, will damp this wobble. Flight test results from Explorer VI show that jet damping stabilizes the vehicle during third-stage burning. The damper will be designed to produce a negligible cone angle buildup during coast periods. Since the spin-axis moment of inertia of the probe is larger than its transverse axis inertia in the ratio 1.2, the attitude of the probe after reorientation will remain stable indefinitely except for small solar-pressure effects. Upper bound calculations indicate an attitude drift, due to solar pressure, of less than 1 degree in 6 months, which is acceptable.

2. Orientation Control

The spinning spacecraft is oriented by a cold gas torquing system so that the earth is in the pattern of the high-gain antenna. Simple sun sensors act as a reference for two axes, and the high-gain antenna provides the third reference. The orientation control subsystem consists of a pneumatic assembly, four sun-sensor assemblies, and an electronics assembly. The subsystem is redundant, and failure of any single component does not prevent orientation or subsequently cause disorientation.

After staging, the first orientation step is completed automatically, pointing the spin axis to within $\pm$ 1 degree normal to the sunline. (The first step can also be initiated by a command.) Calculations of possible perturbations show that step 1 orientation will be maintained throughout the mission without further operation of the orientation control subsystem, although the subsystem will automatically orient if required.

The second orientation step orients the spacecraft such that the antenna is optimally aligned for maximum gain to the earth. This second step proceeds in three stages. After the first orientation step, the first stage of the second step is commanded. Upon reception cf each command, the spacecraft is torqued through about 5 degrees at 0.1 degree per second and then automatically stops. Commands are given to align the antenna pattern parallel to the earth. The first stage is completed using knowledge of the nominal orbit injection parameters.

Next, the second phase of step 2 is commanded. Commands are sent until the maximum gain of the high-gain antenna pattern is realized. The spacecraft transmitter intensity is plotted at the ground station to determine when the spacecraft has rotated just past the maximum transmitter intensity, at which point the reorientation is stopped. The number of degrees (or steps) past the maximum gain is noted and a different command is sent to torque the spacecraft back to the maximum gain point. When the maximum gain point is passed, another command mode of small single firings in the same direction as the second command brings the earth back into the center of the pattern.

Because the commands initiate only small incremental steps, rather than a continuous movement requiring another command to stop, achievement of proper orientation is not jeopardized by a temporary communications interruption.

For either orientation step, the spin-stablized spacecraft is torqued at the proper time of rotation on a signal from the appropriate sun sensor, by a single fixed pneumatic gas jet, during 90 degrees of each spin revolution. Each sun sensor, which is a simple, shaded, on-off device incorporating complete electronic part redundancy, gives only "sun-present" information within its field of view. An "enabled" sun sensor will sense the sun through its rotational acceptance angle and will command the gas jet to fire a constant thrust of gas at a particular phase referenced to the probe-sun line, torquing the spacecraft in a direction normal to the spin axis. By using four sensors, the spacecraft may be torqued in either direction about two orthogonal axes normal to the spin axis. A fifth sensor is used to produce indexing (reference) pulses for the telemetry and the orientation control command logic.

## 3. Thermal Control

The thermal-control system maintains the required internal temperature ($60^{\circ} \pm 5^{\circ}$), and avoids local overheating well under all operating conditions from 0.5 to 2 AU. An active, insulated system, it uses louvers and actuators adapted from the OGO spacecraft, as well as insulation and thermal coatings.

The cylindrical equipment compartment is insulated against the entry of solar heat and the uncontrolled loss of internal power dissipation. A louvered radiator on the underside of the equipment mounting shelf dumps internal power dissipation (plus any heat leakage) into space. Surface coatings, conductive paths, and a carefully planned distribution of heat sources complete the thermal-control subsystem.

Performance analysis of a nonisothermal spacecraft having an active insulated, control system is summarized below.

Equipment Mounting Plate Temperature ($^{o}F$)

| | R = 0.8 AU | R = 1.0 AU | R = 1.2 AU |
|---|---|---|---|
| High Power Mode | 65 | 62 | 59 |
| Low Power Mode | 57 | 55 | 53 |

With improved insulation and minimized conductive paths to portions of the spacecraft exposed to solar flux, internal temperatures can be held to tolerance so that the spacecraft can go to 0.3 AU of the sun.

The equipment compartment is insulated from the solar array by multiple-layer reflective insulation. Such insulation also covers the top of the compartment, that portion of the bottom not given to louvered radiating area, and the part of the antenna mast that passes through the compartment. Wherever possible, structural connections are made with fiberglass. All interior surfaces of the compartment are made thermally "black" for radiative thermal coupling to the equipment shelf. The equipment is arranged for as uniform a distribution of heat sources as is possible within other constraints, and without producing hot spots. The louvers, actuated by individual bimetallic springs thermally coupled to the mounting shelf, are center-balanced and extend radially from the center to minimize spin effects.

Each louver spring is externally insulated to make it responsive only to the local plate temperature. The louvers will have no effect on the magnetometer.

In the fully open position, the highly reflective and specular louver surfaces minimize infrared radiation from them back to the mounting plate. They are also made thermally insulating by five layers of reflective Mylar between the metal louver faces, so that they are closed as a result of low compartment temperature.

The radiating lower surface of the equipment mounting plate is coated with a stable epoxy-based paint such as Cat-a-lac or is anodized, providing a hemispherical infrared emittance of 0.85. The inner surface of that part of the solar array extending below the plane of the louvers is covered by a multiple layer of reflective insulation having an outer layer of 3 mil Mylar, with the aluminized side facing the inside of the cylinder. The smooth, flat, specular surface thus afforded insures maximum radiation away from the mounting plate.

Because the solar array is insulated from the spacecraft, array temperature in nominal flight depend solely on incident energy and array thermal radiation properties. Solar array temperatures listed below are acceptable.

Temperatures ($^{o}F$)

| | R = 0.8 AU | R = 1.0 AU | R = 1.2 AU |
|---|---|---|---|
| Maximum Power Consumption | 138 | 73 | 25 |
| High Power Mode | 144 | 76 | 24 |
| Low Power Mode | 147 | 80 | 30 |

A coating of low $\alpha/\epsilon$ ratio (solar absorptance to infrared emittance) in the area between the cells reduces these temperatures by as much as $20^{o}F$.

4. Data Subsystem

The data subsystem will store and convert engineering and scientific data to a form suitable for transmission to earth.

The data system consists of two parts: a digital telemetry unit (DTU) and a digital storage unit (SU). Figure 5-6 illustrates the fundamentally simple interrelationships between these units. The DTU, shown in Figure 5-6 consists of a clock, a programmer, a main multiplexer and submiltuplexer gates, an analog-to-digital (A/D) converter, a sun counter (for special correlation of input data and determination of spacecraft spin rate), a combiner, and a biphase modulator. The DSU consists of a max/min detector and data storage. Two real-time modes of operation can be provided: a scientific mode, containing 28 prime words and 64 submultiplexed words; and an engineering mode, containing the 64 submultiplexed words only. Seven possible bit rates between 512 and 1 cps can be used in either mode. During periods when the ground stations are not available the DSU, which stores 30,000 bits, permits two modes of operation.

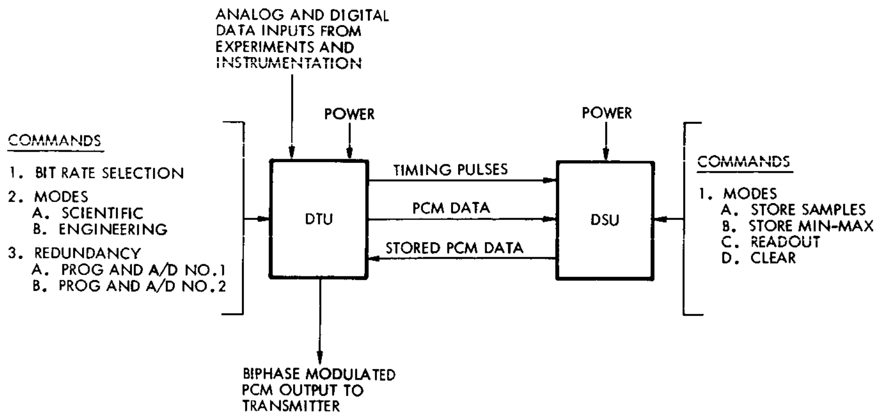



Figure 5-6. Data Subsystem
(30, 000 Bits Storage)

In one mode (max/min), maximum and minimum values of 20 measurements can be obtained together with their time of occurrence during each of 16 equal periods of time spanning up to an 18-hour interval. In the other mode (sampled data), each measurement in the scientific format may be recorded 64 times during the transmitter off-time, providing a maximum time between closest samples of 17 minutes during an 18-hour shutdown. A flexible format which permits the sampling rates between experiments to be altered by command will be a part of the programmer. Similarly, a fast scan mode permits rapid collection and storage of a large number of closely spaced samples during a solar flare or any other time a fine structure analysis is included. These are initiated by command from the earth or by some output or combination of outputs from the experiments themselves.

5. Communication Subsystem

The communication subsystem provides: 1) an efficient communication channel for transmission of data from the spacecraft to the DSIF to a range of at least 100 million nmi, 2) a communication channel to effect the orientation maneuver and to command the subsystems for maximum performance under conditions of both normal and failure mode operation, and 3) tracking information.

A block diagram of the subsystem is shown in Figure 5-7. The subsystem consists of high-gain and omnidirectional antennas, redundant 2300 mc receivers, redundant decoders, redundant 2-level 25 and 10 watt TWT power amplifiers, and a transmitter driver. Either receiver and either power amplifier can be connected on command to either antenna, thus providing full cross-strapping capability. The two receivers operate on slightly different frequencies so that entry is accomplished by frequency address. The demodulated command output of the selected receiver is connected to both decoders and selection of the desired decoder is accomplished by command address. In the noncoherent mode, the transmitter driver can, by command choice, operate either from a separate crystal oscillator or from the rest frequency of either receiver. The TWT power amplifiers can operate at either 25- or 10-watt power levels. Through the use of careful component selection and redundancy, the subsystem has a 0.967 reliability of operating for 6 months in a space environment.

a. Command (Up-Link) Power Budget. The command link provides at 50 million nmi, a 5.7 db performance margin with the low-gain antenna and a margin of 18.7 db with the high-gain antenna. These margins are conservative since they are predicated on a $10^{-5}$ bit error rate, and with the command logic used, the corresponding command error rate is $6 \times 10^{-10}$. The spacecraft can be commanded out to 325 million nmi.

b. Telemetry and Tracking (Down-Link) Power Budget. The telemetry power budget allows transmission over 150 million nmi. At this range the required bit (16 bps) and bit error ($10^{-3}$) rates are obtained with a 3-db performance margin.

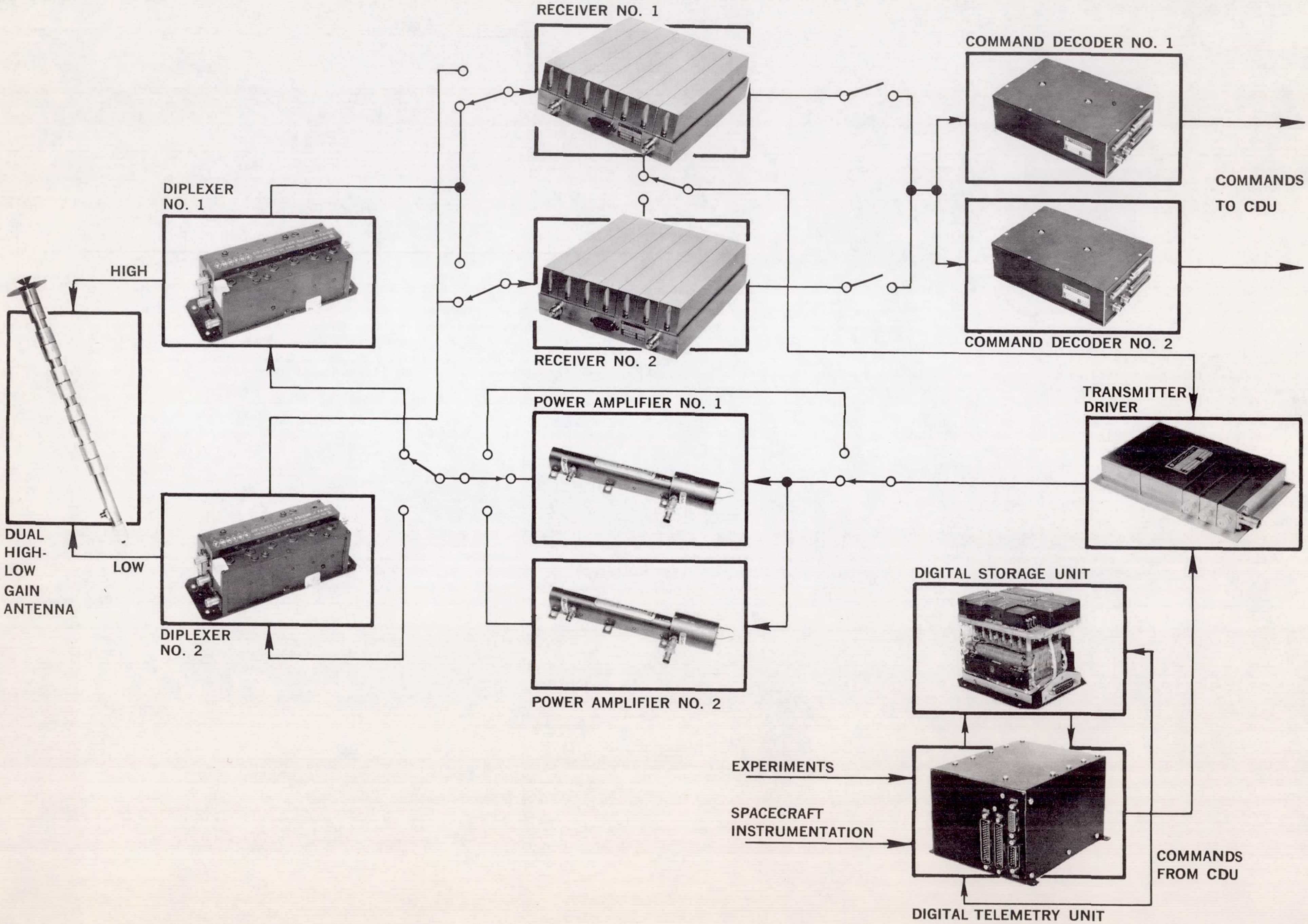



Figure 5-7. Communication System Pictorial Block Diagram.

The 512 bps rate can be used out to 20 million nmi, the 64 bps rate out to 60 million nmi, and the 8 bps rate to 150 million nmi. At 150 million nmi, the carrier signal to noise ratio in the DSIF receiver (noise bandwidth 12 cps) is 6 db; thus, it is probable that data transmission can be maintained at reduced bit rates to a range of about 212 million nmi, and complete loss of phase lock will probably occur at about 306 million nmi. If the DSIF receiver noise bandwidth is reduced below the 12 cps value, a longer range can be expected.

c. Antenna System. The antenna system consists of: 1) an omnidirectional antenna, 2) a high-gain antenna, 3) two channel separation filters (diplexers), and 4) five coaxial latching switches. The omnidirectional antenna provides coverage prior to spacecraft orientation. The high-gain antenna provides a narrow beam coverage (5 degrees beamwidth to the 3 db points) with a gain of 13 db. The diplexers provide sufficient isolation for simultaneous operation of transmitters and receivers on the same antenna. Coaxial switches interconnect and select among receivers, transmitters, and antennas.

A smaller version of the high-gain antenna shown in Figure 5-8 is a modified Franklin array of skirted dipoles consisting of nine driven elements and nine parasitic elements. The omnidirectional antenna, a discone, is mounted at the top of the array and excited coaxially through the high-gain array. The channel separation filters (diplexers) consist of two bandpass filters to isolate the transmitted and received frequencies, as well as for preselection and transmitter spurious radiation rejection.

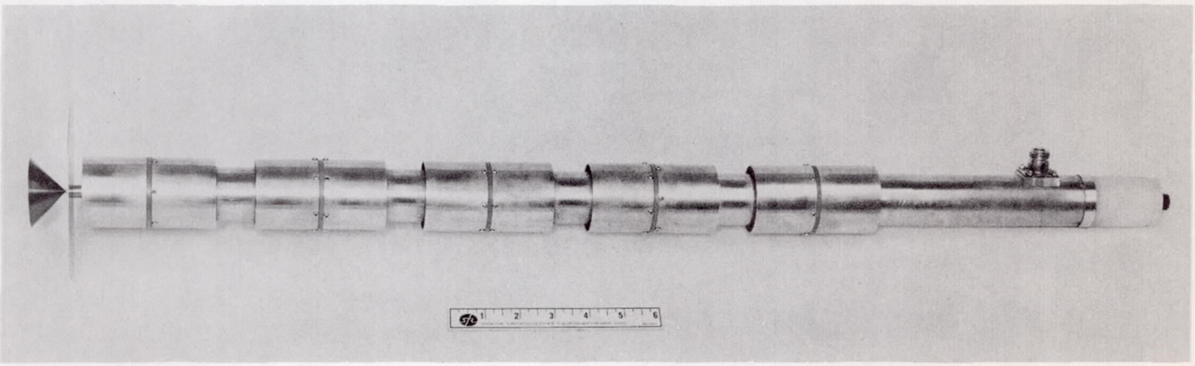


Figure 5-8. Ten-Element Franklin Array

Fail-safe coaxial switches are used to select the desired receiver-transmitter antenna combination. These switches feature a latching mechanism for positive switching, and require electrical power (6 watts) only during the switching phase (20 milliseconds).

d. Receiver. The spacecraft command receiver provides a coherent drive to the telemetry transmitter permitting a precise measurement of two-way doppler shift; and, secondly, efficiently demodulates the command information and provides a suitable output to the command decoder. A block diagram of the receiver is shown in Figure 5-9.

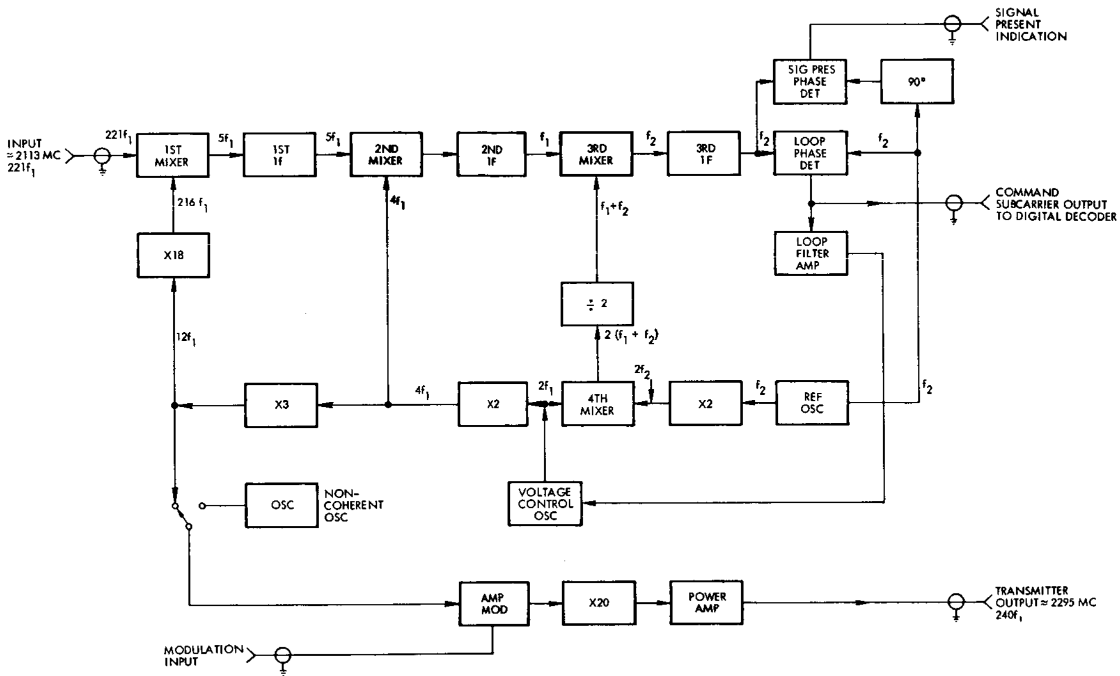



Figure 5-9. Spacecraft Command Receiver.

The transmitter is shown on the abbreviated block diagram (Figure 5-10). The 115 mc drive is obtained from the receiver assembly at a 2-milliwatt level and is amplified and modulated in a solid-state driver which produces an output power of 500 milliwatts. This signal is applied to the X20 varactor multiplier which supplies 50 milliwatts output at 2295 mc to drive the TWT final amplifier. For missions going away from the sun, two operating modes are included in the final design amplifier for extra reliability in the event of solar-array degradation beyond normal expectations. Output powers of 25 and 10 watts are available. The output of the varactor driver is connected directly to the antenna prior to the orientation maneuver so as to minimize battery drain and avoid activation of the high voltage supplies at the critical altitude. The driver weighs 12 ounces, occupies 15 cubic inches, and consumes 1 watt. A single TWT with bracketry weighs 14 ounces and occupies 15 cubic inches.

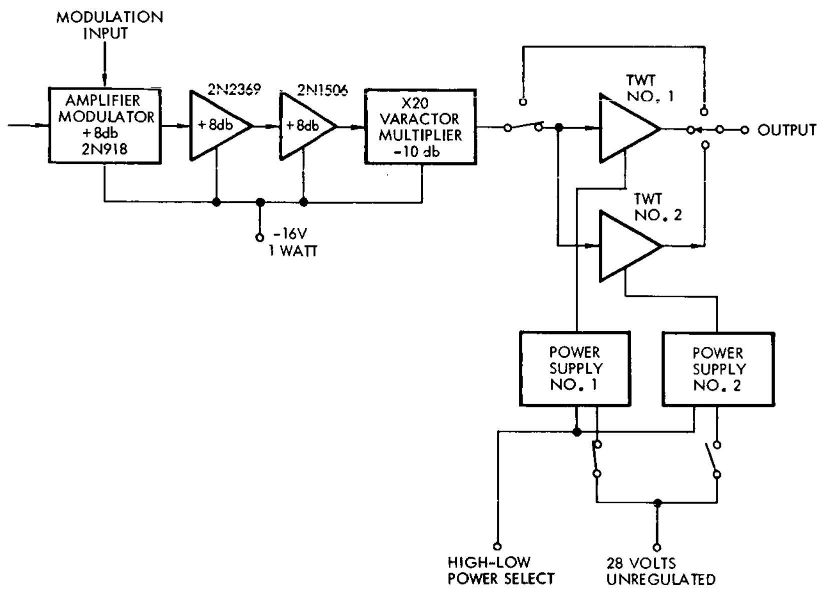



Figure 5-10. Transmitter Block Diagram.

e. Command Decoder. The command system, with a capability of 64 discrete commands, makes use of the existing Ranger command encoding equipment located at all DSIF stations and the AF 823 command decoder. Utilizing an 18-bit message which FSK's a 150-cps subcarrier, the following functions are provided: 1) selection of one of the two redundant decoders, 2) selection of the spacecraft, 3) selection of one of the 64 discrete commands using bit-by-bit parity check, thus providing ahigh immunity to false commands, 4) command execute or dump as verified by the ground station transmitter monitor.

The decoder accepts the command signal from either receiver and demodulates the digital message. The output consists of appropriate pulses to drive an 8 x 8 silicon controlled rectifier matrix located in the command distribution unit. A block diagram is shown in Figure 5-11.

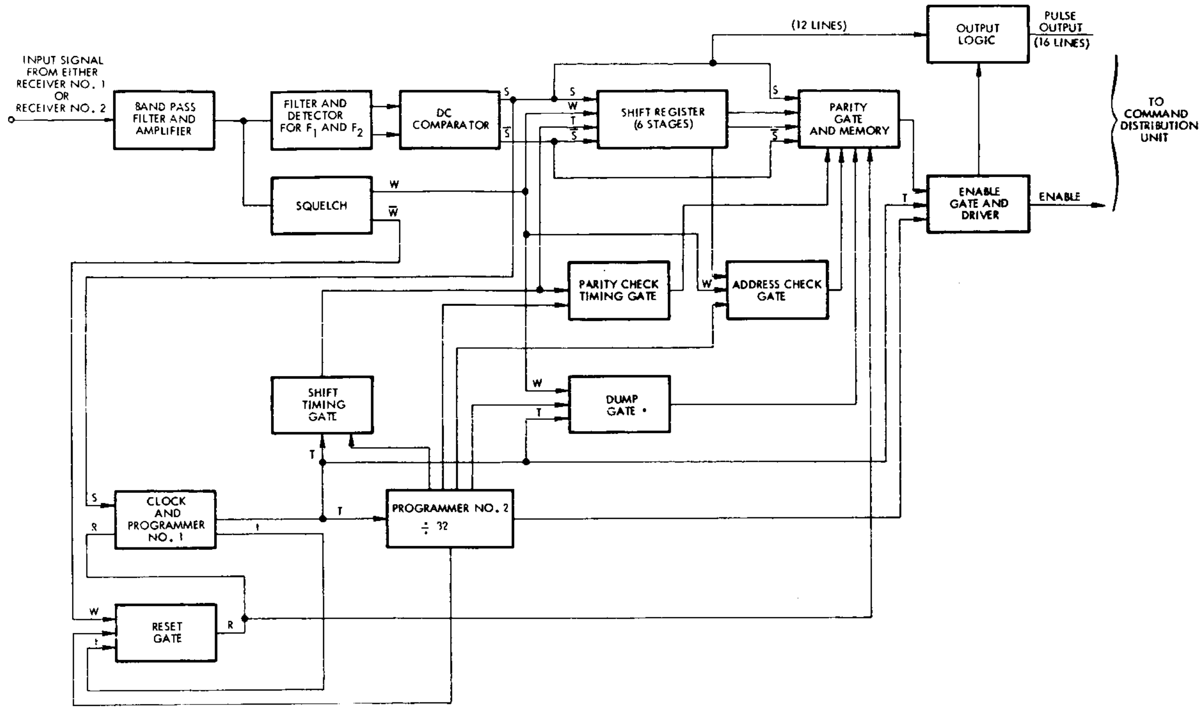



Figure 5-11. Command Decoder Block Diagram

## 6. Electrical Power Subsystem

The electrical subsystem provides electrical power from a battery prior to solar-array orientation; converts solar energy to electrical energy; distributes electrical signals and commands; interconnects the various spacecraft equipment; converts primary electrical power to regulated voltages; and provides power fault protection.

The subsystem consists of a solar array, batteries, converter-regulators, the CDU, and cabling. The solar array is assembled from modules similar to those STL is using for OGO. The batteries, cable assembly components, converters, and command distribution unit are all standard items.

The chief features of the subsystem are: 1) it affords ample power margins over system loads; 2) gives high reliability by providing protection against effects of failures either in loads or power-subsystem components; 3) after launch, the batteries represent only a backup mode; and 4) parallel strings of solar cells ensure reliability through redundancy.

Figure 5-12 is a block diagram of the electrical subsystem. Table 5-1 gives the power and voltage requirements. The battery is used for system power (it load-shares with power available from the array) only until the solar-array output exceeds the battery voltage. It will then be commanded off until required either for a mission far from the sun or for high loads in the vicinity of the comet. Two redundant converters—one for each power

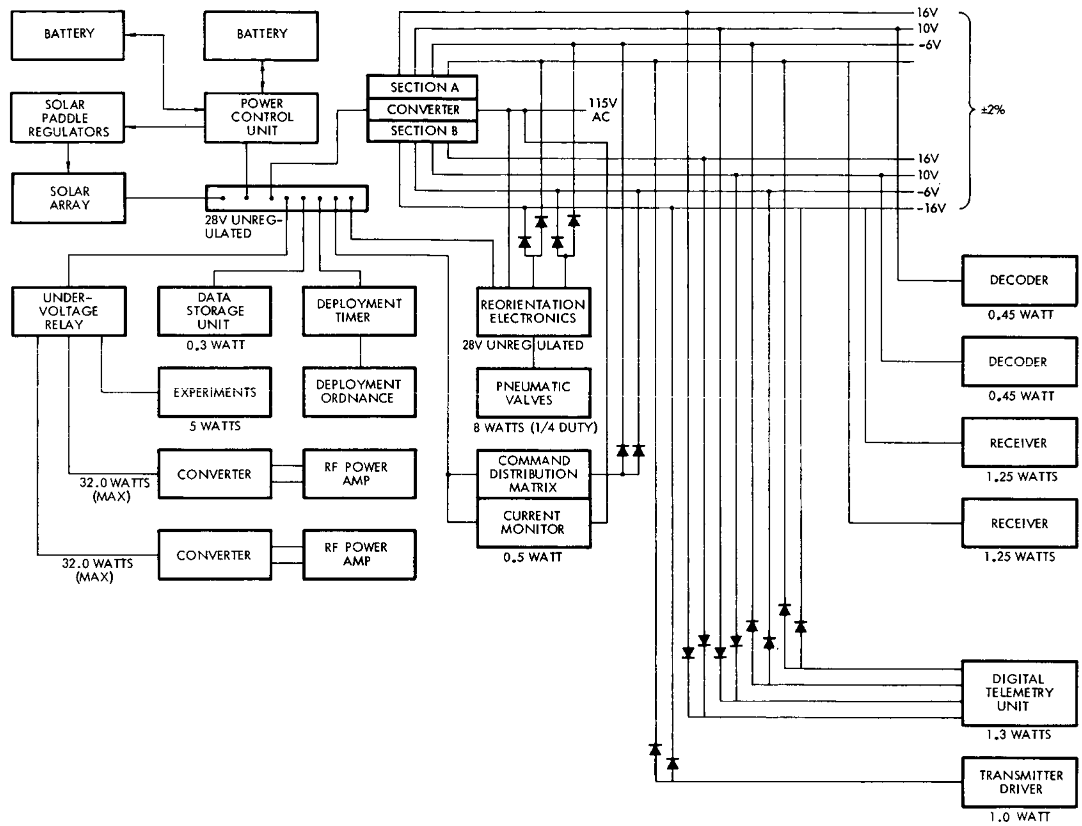



Figure 5-12. Electrical Subsystem Block Diagram

amplifier and one containing redundant converters for all other loads—are provided. The CDU serves as a central control point for all distribution, power control, command-control signals via the command matrix, under-voltage relay, and associated control relays.

An under-voltage relay removes the experiments and power amplifiers from the unregulated bus in the event of a fault or if the solar array output should degrade catastrophically. This removal of loads from the solar array allows for additional fault-clearing capacity without interrupting the ground-spacecraft command capability. The under-voltage relay can be bypassed by ground command, and equipment turned off by the under-voltage relay can be turned on only by ground command.

Even if the array should degrade more than predicted, the transmitter load can be commanded to a lower power, and the capability for satisfactory communication would still exist.

Table 5-1. Power Loads

| | | |
|---|---|---|
| **Continuous Loads** | | |
| Receivers (2) | 2.5 watts | -16 volts |
| Decoders (2) | 0.9 watts | 10 volts |
| Driver | 1.0 watts | -16 volts |
| DTU | 1.4 watts | -16, -6, 10, 16, -16 volts |
| | 5.8 watts | |
| Bus load (average converter efficiency) | 9.4 watts | |
| Experiments (bus) | 11.0 watts | |
| DSU (bus) | 0.3 watts | |
| CDU (bus) | 0.5 watts | |
| | 21.2 watts | |
| **RF Amplifier** | 25 watt output | -1020, -520, 60, 5.4 volts |
| | 10 watts at bus | |
| | Total | 121.2 watts |
| | with 10 watt output- | 71.2 watts |

Figure 5-13 shows the solar array power capability versus array voltage for the parameter of distance from the sun, and the range voltages for these conditions. The I-V curves of array output capability were calculated for the appropriate solar energy intensity levels and the calculated solar cell temperatures. Table 5-2 gives the detailed assumptions used in arriving at the final array output.

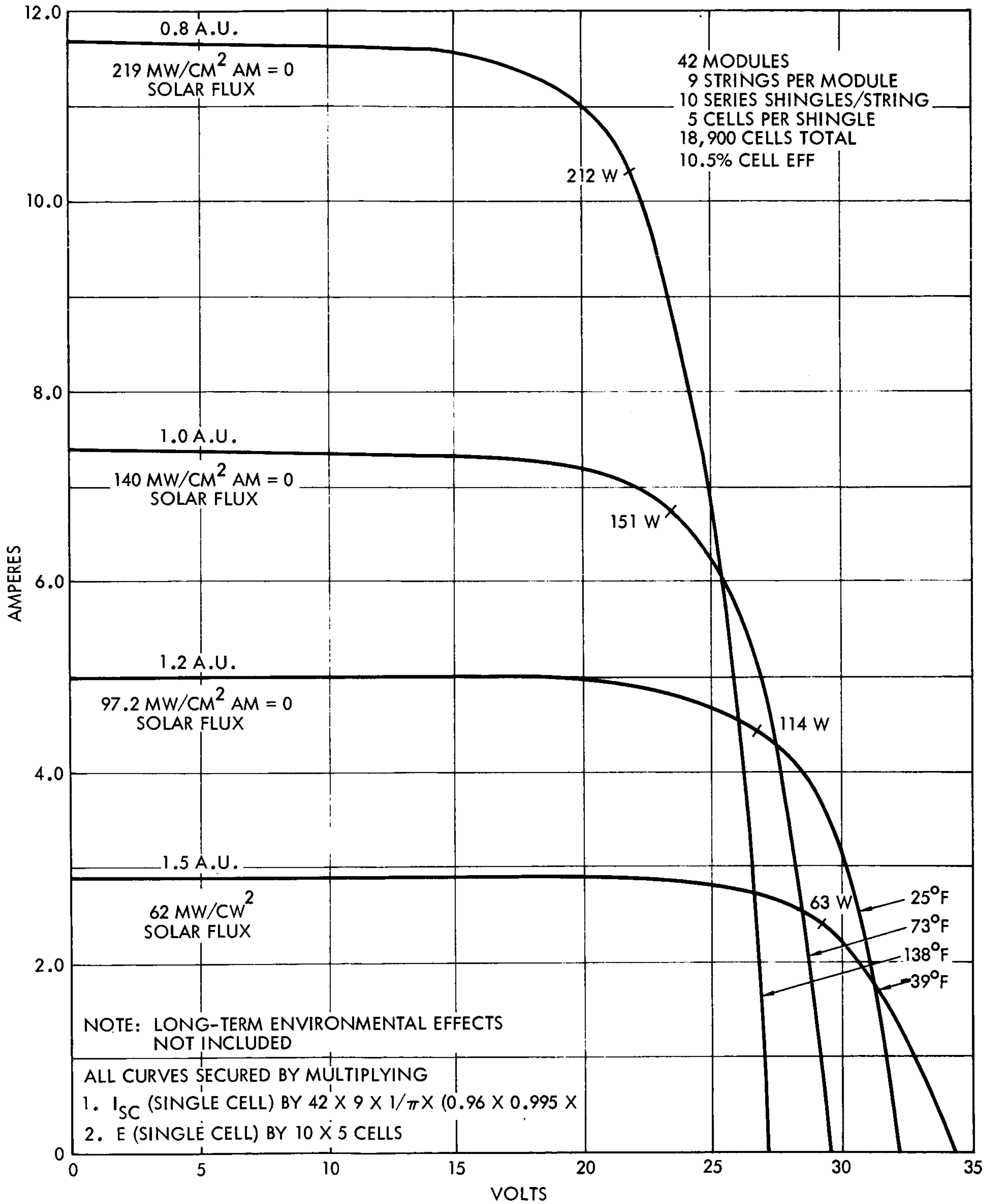



Figure 5-13. Solar Array Power Capability Versus Array Voltage.

Table 5-2. Solar Array Performance Factors

| | |
|---|---|
| Transmission factor (including losses in cover glass, ultraviolet filter, and adhesive, and the reflection losses due to the curvature of the array surface) | = 0.92 |
| Radiation degradation factor (solar protons, 6 months) | = 0.95 |
| Diode loss factor | = 0.98 |
| Impedance mismatch factor (mismatch of shingles and strings resulting in less than maximum power transfer) | = 0.96 |
| Product | 0.822 |

Solar Constant:

at 0.8 AU: 219 $mw/cm^2$
at 1.0 AU: 140 $mw/cm^2$
at 1.2 AU: 97.2 $mw/cm^2$
at 1.5 AU: 62 $mw/cm^2$

Equilibrium temperature and temperature factor:

| | Cover glass with blue filter | |
|---|---|---|
| at 0.8 AU | 138°F | 0.832 |
| at 1.0 AU | 73°F | 1.027 |
| at 1.2 AU | 25°F | 1.17 |
| at 1.5 AU | -39°F | |

Array output: (cell area = 1.8 $cm^2$) 11 percent efficiency cell. Only $1/\pi$ of all of circular array effectively normal to incident radiation. Then

| Array Output at Bus after 6 months | 9900* Cells |
|---|---|
| at 0.8 AU | 200 watts |
| at 1.0 AU | 142 watts |
| at 1.2 AU | 103 watts |
| at 1.5 AU | 63 watts |

* The possible 10,000 cells are reduced to 9900 because of sensor windows in the array surface.

7. Midcourse and Terminal Correction Engine

A compact and efficient spacecraft injection engine, designed, built and used by STL in the Able-5 moon probe, will be used for midcourse trajectory adjustment (vernier velocity) in either direction along the spin axis prior to reaching the vicinity of the comet. Ignition is commanded by radio from the ground. Hydrazine is used as the monopropellant. Two nozzles, one at each end of the spacecraft along the spin axis, are fed from a single hydrazine reservoir which is pressure-fed by nitrogen bottles. The engine has a capability of six starts.

The thrust level of the engine is nominally 18.5 pounds. The measured specific impulse is 230 seconds. The thrust chamber and nozzle are uncooled and have been operated from periods in excess of 30 minutes. The nozzle has an expansion ratio of 50:1.

The total weight of the unit is approximately 40 pounds; tankage is provided to carry a maximum of 140 pounds of hydrazine. The system furnishes a total of about 25,000 lb-sec of impulse. The firings are completely independent and may be performed at any time or in any sequence required.

The rocket uses a regulated pressure system consisting of four 200-psia nitrogen spheres which also supply the reorientation subsystem, a pressure regulator set at 250 psia, and six explosive-actuated valves.

8. Spacecraft Weights and Mass Properties

Table 5-3 itemizes the weight of the comet spacecraft and associated booster weights.

Table 5-3. Spacecraft Weights and Mass Properties

| | | Weight, Lb. |
|---|---|---|
| Structure | | 46.0 |
| Skin | 8.0 | |
| Rings (3) | 6.0 | |
| Top Cover Plate | 3.0 | |
| Antenna Supports and Internal Structure | 1.0 | |
| Equipment Platforms and Mounting Brackets | 20.0 | |

Table 5-3. Spacecraft Weights and Mass Properties (Continued)

| | | Weight, Lb. |
|---|---|---|
| Adapter Ring Cylinder and Flanges | 5.0 | |
| Damper | 1.0 | |
| Miscellaneous Hardware | 2.0 | |
| Communications | | 26.5 |
| Coax Switches (5) | 0.9 | |
| Diplexer (2) | 1.4 | |
| Receivers (2) | 7.5 | |
| Command Decoders (2) | 4.8 | |
| Digital Telemetry Unit | 5.4 | |
| Data Storage Unit | 1.8 | |
| Power Amplifiers (2) | 1.6 | |
| Driver | 0.8 | |
| Antennas (Includes 24" ext.) | 2.3 | |
| Electrical System | | 61.0 |
| D-C to D-C Converter No. 1 (2) | 2.0 | |
| D-C to D-C Converter TWT No. 2 (2) | 5.0 | |
| Command Distribution Unit | 6.0 | |
| Batteries | 40.0 | |
| Cabling and Connectors | 8.0 | |
| Orientation System | | 4.4 |
| Sun Sensors | 0.8 | |
| Logic (0.8 lb in CDU) | --- | |
| Pressure-Transducers and Switch | 0.4 | |
| Pressure Regulator | 1.1 | |
| Plumbing and Supports | 0.6 | |
| Valves | 1.5 | |
| Propulsion | | 185.0 |
| Motor and Plumbing | 26.0 | |
| Tanks & $N_2$ Gas | 16.0 | |
| $N_2$ Gas | 13.0 | |
| Hydrazine | 130.0 | |
| Temperature Control | | 6.0 |
| Louvers and Structure | 3.5 | |
| Linkage and Miscellaneous | 0.5 | |
| Insulation | 2.0 | |
| Solar Cell Array | | 30.0 |
| Cells, Class, Wire Adhesives, Substrate | | |
| Balance Weights (Internal) | | 10.0 |
| Total Spacecraft Weight Less Contingency and Experiments | | 368.9 |
| Contingency (5%) | | 18.0 |

Table 5-3. Spacecraft Weights and Mass Properties (Continued)

| | | Weight, Lb. |
|---|---|---|
| Total Spacecraft Weight With Contingency, Less Experiments | | 386.9 |
| Experiment Package | | 46.0 |
| TV | 7.0 | |
| Micrometeorite | 10.0 | |
| Plasma Probe | 8.0 | |
| Magnetometer | 13.0 | |
| Mass Spectrometer | 8.0 | |
| Total Separable Spacecraft Weight With Contingency and Experiments | | 432.9 |

Note: Douglas interstage of 9.5 lb is not shown as part of separable spacecraft.

## 9. Interaction with Space Environment

The physical environment that the comet spacecraft will encounter in space has been examined for influence on performance. It is clear that the deleterious effects of the space environment have been overcome by prudent design and selection of materials and components.

The comet spacecraft will be subjected to four major environmental conditions. First is the solar heat flux, which has been controlled by judicious thermal-control materials design. Second is the ultrahigh vacuum of outer space, with its resultant material sublimation and reduction in contact lubricity between friction surfaces. These effects have been negated by a design which isolates lubrication from space environment, and the selection of surfaces and lubricants known to be compatible with the spatial environment. For example, of the metallic structural materials used (aluminum alloys, magnesium, stainless steel and beryllium), magnesium has the highest vapor pressure, yet the loss of magnesium over a 1-year period is negligible. The fiberglass epoxy laminate , a nonmetallic structural material, will incur some weight loss. This will produce a minor reduction in structural strength, which has been allowed for. The louver bearing assembly employs solid lubricants developed for the OGO program. This assembly has been laboratory-tested in vacuum and shown to maintain the required frictional conditions. Third is the problem of meteorite and micrometeorite impact and penetration. However, an estimate of this hazard, based on latest available data, indicates that the possibility of these particles disabling the spacecraft structure during its lifetime is extremely small. The fourth and most significant factor is that of charged-particle radiation, particularly resulting from solar flares. Change in structural properties of both the metallic and nonmetallic components owing to radiation damage has been assessed as negligible. The Pioneer radiation dosages are several orders of magnitude below the threshold damage levels for any of the structural materials. Maximum structural loadings occur upon launch and orientation. Following the operational phases, demands on structural strength are minimal. Thus the minor cumulative effects on structural properties caused by vacuum and radiation are not threatening to the spacecraft.

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# COMET INTERCEPT STUDY

N63 16229

NASw-414

APPENDIXES

OTS PRICE

XEROX $ 16.00 ph

MICROFILM $ 2.20 mf

SPACE TECHNOLOGY LABORATORIES, INC.
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# COMET INTERCEPT STUDY

# FINAL REPORT

**NASw-414**

8668-6003-RU-000

APPENDIXES

**28 MARCH 1963**

SPACE TECHNOLOGY LABORATORIES, INC.
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## APPENDIX A

## OUTLINE OF A CONTAMINATION EXPERIMENT FOR STUDYING THE MAGNETIC STRUCTURE OF A NATURAL COMET

The performance of experiments in a comet is fundamentally limited by the short time during which a probe may stay in the close neighborhood of the comet. The dynamical conditions of an encounter also are such that only a very small part of a comet can be directly probed at a given time. It is, therefore, of interest to investigate the possibility of contaminating the comet material with a trace substance, that may "ride" with the comet for several days, to an extent that it may be observed from the earth or from the probe itself. The purpose of this note is to suggest the general foundations for such an experiment and to show that the amount of contaminating substance needed is within the payload limitations existing today.

The reasons for believing that a magnetic field exists in the coma and the tail of a comet are varied (Alfvén 1957; Hoyle and Harwit 1962). The actual topology of the magnetic fields, as well as their strengths, is so far only conjectural, but in order to understand the multifarious phenomena observed in the structure and development of the comae and tails, nearly all recent investigators agree in believing that forces of magnetic origin play a fundamental role. Besides an inner magnetic field set up by the streaming motions of cometary ions, there must exist a boundary layer where the strength of the interplanetary magnetic field has been increased considerably (at least by an order of magnitude) by compression.

The essential idea of the suggested experiment is to make use of the cometary magnetic field to trap ions produced by solar photoionization of material released from a probe. The observation of solar radiation resonantly scattered by these ions would provide information related to the manner in which the ions are diffused throughout the comet and hence about the nature of the forces acting on them. The large-scale features of the cometary magnetic field, which is expected to have lines of force along the tail, could thus be studied over an interval of time much longer than the time during which direct magnetometer measures could be made. We propose to estimate the mass M of material to be released under the requirement that it is to be observed over a given interval of time. Following Biermann, Luest and Schmidt (1961), we shall suppose that the material to be released is an alkali, Calcium, Strontium or Barium, in atomic form. The reason for choosing these atoms is that their first ionization potential is low, while their second is very high. At 1 AU from the sun, the lifetimes $\tau_i$ of these atoms against solar photoionization are 20, 10, and 2.7, minutes respectively, and at the low densities we shall be concerned that the ions formed remain in the singly ionized state and essentially in their lowest energy level, where they may scatter solar radiation in their resonance lines, which are at $\lambda\lambda$ 3933 and 3968 A for Ca, $\lambda\lambda$ 4077 and 4215 A for Sr, and $\lambda\lambda$4554 and 4934 A for Ba. The probabilities for resonance scattering $a_s$ of solar radiation at 1 AU from the sun are 0.9, 0.3 and 0.15 $\sec^{-1}$, respectively for the three ions in order of increasing mass (Biermann et al, 1961).

Let the nominal time of collision between probe and comet be $t_o$, and suppose the mass M is released effectively in atomic form at a time $t_1$ such that $\tau_i < t_o - t_1$. If released with a small relative velocity, the parent atoms and their ions will keep traveling along the same orbit as the probe, except that the released matter will expand nearly at a rate set by their rms thermal speed

$$V_t = \sqrt{\frac{8\,k\,T}{\pi\,A\,m_H}} \qquad (1)$$

where T is the temperature, k is Boltzmann constant, $m_H$ is the mass of the hydrogen atom and A is the atomic weight. The temperature after their photoionization and thermalization has been estimated by Biermann et al (1961) at 2000$^o$K, and the corresponding values of $V_t$ are 1.0, 0.68 and 0.54 km/sec, respectively for the three ions of mass 40, 88, and 137. The use of equation (1) to estimate the expansion of the cloud is justified on the grounds that over a large fraction of the interval $t_o - t_1$ the kinetic mean free path will exceed the dimensions of the cloud. In this context it may also be mentioned that a sodium cloud ejected from the second Soviet cosmic rocket was observed from ground, from a distance of 135,000 km, to expand at a mean rate of 1.3 km/sec (Kachiyan, Kalloglyan, and Kazaryan, 1959). The expansion and motion of the ion cloud will be unaffected by interplanetary magnetic fields if its kinetic pressure exceeds the magnetic pressure, a situation which will be verified for the densities derived below, when the magnetic field is of the order of $10^{-5}$ Gauss. The time of release, then, may be estimated assuming uniform expansion at a rate $V_t$. If the cloud is required to have linear dimensions $L_o$ when it reaches the vicinity of the comet we then have:

$$t_o - t_1 = \frac{L_o}{V_t} \qquad (2)$$

If the minimum detectable number of ions along the line of sight is $N^*$ ($cm^{-2}$), at $t_o$ we should have:

$$M = \frac{\pi}{6} L_o^3 n(t_o) A m_H < \frac{\pi}{6} L_o^2 N^* A m_H , \qquad (3)$$

where n(t) is the density ($cm^{-3}$). In order to have an idea of the numbers involved, let us take $L_o = 2000$ km. At a distance R = 0.1 AU, the cloud would appear then to subtend an angle of 28 arc/sec. From equation (2) then we obtain $t_o - t_1$ to be 35, 50 and 60 minutes for the three substances. Adopting $N^* = 2 \times 10^9 \, cm^{-2}$, an amount more than enough to be easily detectable, we find M = 2.8, 6.1 and 9.5 kg, respectively, and the number densities $n(t_o)$ are of the order of 10 $cm^{-3}$. When the ion stream at these densities encounters the cometary magnetic field, assumed to be the strength $B = 10^{-4}$ Gauss, in a transverse direction, and with a velocity $V_o$ equal to the terminal velocity between comet and probe, the ions will gyrate with radii

$$r_g = A V_o \frac{m_H c}{eB} = 3 A \times 10^7 \text{ cm}, \qquad (4)$$

distance which is much smaller than the dimensions of the comet. Since the dynamic pressure of the stream also is smaller than the magnetic field pressure, it is seen that the ions will be indeed trapped in the comet, or in the region where the field is compressed to give rise to the coma and tail.

The development of the ionized alkali cloud following its capture by the comet will be set by diffusion and drift along the lines of force. Essentially it will thus expand only in one dimension, along the tail, with a speed nearly equal to $V_t$. If the line of sight is perpendicular to the tail, at a time t such that $t - t_o > t_o - t_1$, the number of atoms $N_\perp(t)$ in a column of unit cross section will be:

$$N_\perp(t) = \frac{M}{A m_H L_o V_t (t - t_o)} . \qquad (5)$$

If the comet, on the other hand, is observed along the line of sight, $N_{11}$ (t) would remain essentially constant, except for the fanning out of the lines of force and drift, but certainly would decrease more slowly than $N_{\perp}(t)$. Considering only the more unfavorable case, we require then that for a given time $t_m$, N $(t_m)$ just equals the minimum detectable number:

$$M = N^* L_o A m_H V_t (t_m - t_o) \qquad (6)$$

Since $t_m - t_o$ will be required to be larger than $t_o - t_1$, so as to observe the ion cloud for a reasonable time, the mass M defined by equation (6) may be larger than that found above from equation (3).

We shall now fix the value of N*, by considering the practical aspects of detection of a signal I*, expressed in Rayleighs R (1R = $10^6$ photons/cm$^2$sec. steradian). We are dealing with the detection of an emission line with a spread set by the Doppler effect of the ionic motions, and it amounts thus to a few tenths of an Angstrom. The signal has to be discriminated against external noise, set by sky brightness and cometary brightness in the case of ground observations, and in the case of observations from the probe, by cometary brightness alone. In either case, we are not limited by dark noise in the detectors, unless a monochromator of very high spectral resolving power were available. The possibility of developing a resonant detector cell, such as the Blamont magnetic scanner, should be explored in detail. But for the time being let us suppose that a pass band $\delta\lambda$ a few Angstroms in width is isolated around the line concerned by means of a multilayer interference filter or a grating monochromator of the Ebert-Fastie type.

In the case of detection from ground, the ultimate surface brightness detectable is set by the airglow and the natural brightness of the comet. We are implicitly assuming that the observations are made on moonless nights, of course. Since we are interested in detecting the contaminating substance in the faintest parts of the comet (the tail), we can take only the airglow as signal noise. Because of auroral emission of $N_2^+$ at $\lambda$3914A and the $CO^+$ cometary bands (tail bands) around $\lambda$4100A are not far from the resonance lines of $Ca^+$ and $Sr^+$, it would appear that the case of the Ba $\lambda$4554A line is the most favorable to consider. The surface brightness of the airglow around $\lambda$4554A is $I_b$ = 0.04R/A (Chamberlain 1961). We set then the minimum specific intensity of the resonantly scattered radiation in the ion cloud equal to the external noise intensity

$$\frac{N^* a_s}{4\pi} = \delta\lambda \; I_b \quad , \qquad (7)$$

corresponding to a signal to noise ratio of unity. If the pass band $\delta\lambda$ is measured in Angstroms from (7), we have:

$$N^* = 3.4 \times 10^6 \text{ cm}^{-2} \quad , \qquad (8)$$

and from equation (6) we obtain the minimum mass $M(t_m)$ of $Ba^+$ ions needed to be detectable up to time $t_m$:

$$M = 0.366 \; L_o \; (t_m - t_o) \; \delta\lambda \qquad (\text{Kg/km. A. day}), \quad (9)$$

where $L_o$ is expressed in thousands of kilometers and $t_m - t_o$ in days.

We still have to fix the conditions of detection in such a manner that the amount of radiation reaching the detector exceeds by some factor k the dark noise. For an efficient blue sensitive photomultiplier, operating at dry ice temperatures, the equivalent dark noise $E_o$ is about 100 photons$\pi$sec. We should then require a telescope with aperture D and a diaphragm at the focal plane with angular measure $\omega$ such that

$$\frac{\pi^2}{16} D^2 \omega^2 \delta\lambda \; I_b \geqslant k \; E_o \quad , \qquad (10)$$

where the number k depends on the technique used to filter the signal from the dark noise (time constant) and also includes reflection and transmission losses in the optical system. The focal length of the telescope F, on the other hand, should be such that the angle in the sky subtended by the entrance diaphragm is not larger than the smallest angular dimension of the ion cloud in the comet:

$$\omega = \frac{d}{F} < \frac{L_o}{R} \quad , \qquad (11)$$

where d is the linear diameter of the diaphragm. Reflecting telescopes with D = 40 inch and Cassegrain focci with F/D = 15 are found in observatories fairly well distributed over the entire world, and could be used for continuous coverage. With such a telescope, a diaphragm with d = 2 mm just satisfies (11) for $L_o$ = 2000 km, and equation (10) would give

$$\frac{\delta \lambda}{k} > 23 \qquad (12)$$

We see thus that with $\delta\lambda$ = 20 A, we would begin to be dark noise limited, and the mass required would be

$$M = 14.2 \, (t_m - t_o) \qquad (\text{kg/day}) \qquad (13)$$

If the telescope aperture were increased to 80 inches, then the mass requirement would decrease by a factor 4. It would appear, in any case, that the amount of contaminating substance needed for ground observations extending over two or three days could be part of a realistic payload.

The conditions for detectability by observations from the probe are quite different, because the light collector used would have to be no larger than - say- D = 6 inch, and for an unrefrigerated photomultiplier we would have $E_o = 10^4$ photons/sec. These are not the most serious limitations, however, as the noise would not be dark, but the natural brightness of the comet itself. If the vehicle is only spin stabilized, the entrance aperture to the detector would have to be at least an order of magnitude greater than for ground detection, and the noise would then be a factor of $10^2$ larger than before. For a telescope with D = 15 cm, F = 225 cm and d = 2 mm, the contaminant would be observable but only for a distance satisfying (11), or from less than 225,000 km. Since the probe and comet have a relative velocity of 15 km/sec, the corresponding time would be only 4 hours. It appears thus that the observation from ground is much more advantageous than from the probe.

In this brief survey we have not considered the actual mechanism through which the required mass could be released in atomic form. The history of the contamination experiments of the upper atmosphere (Marmo, Aschenbrand, and Pressmann, 1959, 1960) should give us confidence towards finding an explosive chemical reaction that can produce the release efficiently.

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# APPENDIX B

## ORBIT OF COMET ENCKE

The following is a print-out of the Orbit of Comet Encke from December 1960 to December 1967. Since an already existing computer program was used in which the comet was substituted for a spacecraft, many quantities were printed, some of which are not very useful.

## FREE FLIGHT TRAJECTORY DEFINITIONS

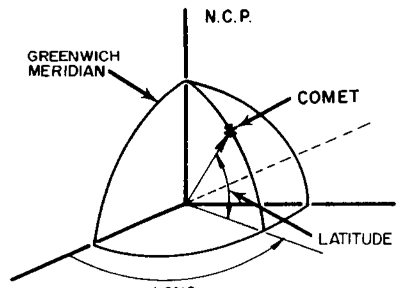


FIGURE 1

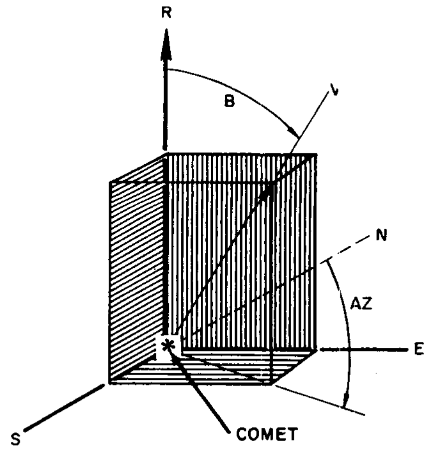


FIGURE 3B

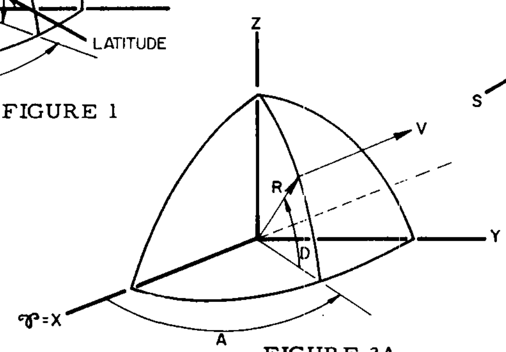


FIGURE 3A

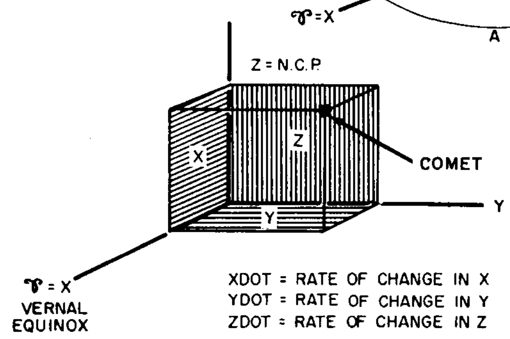


FIGURE 2

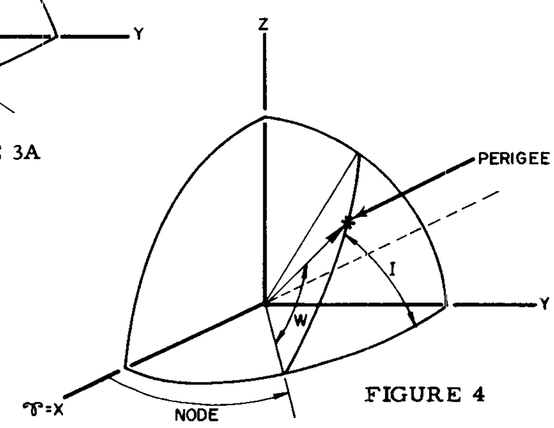


FIGURE 4

LINE 1

The time is GMT. Time-Start is minutes from epoch

LINE 2

LAT - North Latitude } See Fig. 1
LONG - East Longitude }
V.APO - Velocity at Apogee
V.PERI - Velocity at Perigee
(DEG) - Degrees
(FPS) - Feet per Second

LINE 3

ALT - Altitude = Height from earth's surface to Comet
APO - Apogee = Farthest point in the trajectory from the earth's mean equatorial radius
PERI - Perigee = Nearest point in the trajectory from the earth's mean equatorial radius
PERIOD - Time in minutes for one revolution
(NM) - Nautical Miles
(MIN) - Minutes

LINE 4

See Fig. 2 (measured in AU and AU/sec)

LINE 5

See Fig. 3A and Fig. 3B (measured in AU, AU/sec, and degrees)

LINE 6

A - Semimajor axis of trajectory (AU)
E - Eccentricity
I - Inclination (degrees)
NODE - Longitude of the ascending node (degrees)
W - Angle between line of nodes and major axis of trajectory, also called omega (degrees)
M - Mean anomaly (radians)
See Fig. 4

LINE 7

R = Earth center to Comet distance (statute miles)
V = Comet velocity wrt rotating earth (meters/sec)
G = Earth fixed path angle (deg)
S = Earth fixed Azimuth angle (deg)
SVE = Sun- Comet -earth angle (deg)
F = True anomaly (deg)

LINE 8

EARTH LOOK }
MOON LOOK } Nonrelevant
SUN LOOK }
RM = - Distance from Comet to moon (earth radii)
RS = - Distance from Comet to sun (earth radii)

LINE 9

ETA, ZETA, } Nonrelevant
RHO, XPRIME }

LINE 10 and 11

XMV, YMV, ZMV - X, Y, Z distance from moon to Comet
XM, YM, ZM - X, Y, Z of moon
XSV, YSV, ZSV - X, Y, Z distance from sun to Comet
XS, YS, ZS - X, Y, Z of sun
Units are earth radii.

```
                    STARTING DATE  12   DECEMBER 1960       HOURS      MIN    .00 SEC     GMT

                              ALPHA G   80 DEG. 41 MIN  37 SEC  =  80.69352 DEG.

TYPE       X              Y              Z              XDOT           YDOT           ZDOT

 -3    .47966325 12   .26032625 12   .23346641 12   -.10669931 06   .69070015 04   -.71312224 04

        RADIUS          ALPHA          DELTA             V             BETA      .       A

       .59359343 12   .28489884 02   .23160633 02    .10716018 06   .14336931 03   .62995440 02

            XIX= -.99569923  XIY=  .06445502  XIZ= -.06654724       BBO 143.369        ABO= 62.995

                                              NO KICK

                                              NO DRAG

NODE RATE(DEG/DAY)  .31920136-14  PERIGEE RATE(DEG/DAY) .45886125-14  ANOMALISTIC PERIOD(MIN) .10015908 10

12 DECEMBER     HR     MIN  - SEC TIME-START  .00000000 00  JULIAN DATE 1280.5000
LAT(DEG)  .58908380 01  LONG(DEG) .25525302 03   V.APO(FPS) .32731550 02  V.PERI(FPS) .39529018 03
ALT(NM)   .71432433 08  APO(NM)    .33071409 09   PERI(NM)   .27381242 08  PERIOD(MIN) .10015908 10
X  .80335833 00  Y -.35857684 00 Z    .90163560-01   XD  -.18133838-07   YD  -.17632142-07 ZD -.28272388-07
R  .88435932 00  A -.24053467 02 D    .58516747 01    V   .37934897-07 BETA   .10876976 03 AZ  .22084846 03
A  .22166105 01  E  .84705660 00 I    .34998881 02 NODE  -.91697406 01    W  -.19200392 03  M -.28972694 00
R  .16749230-03  V  .64175959-04 G   -.10897986-01    S   .26997573 03  SVE   .53392322 02  F  .23529734 03
ELK  .15962257 03 MLK  .11207396 03 SLK  .14336931 03  RM  .16267469 05 RS  .28365556 05          ELLIPSE
ETA  .25769735 00 ZTA -.17223091 00 RHO  .20438709 05  XP  .34374838 04               VEHICLE IS NOT ECLIPSED
XMV  .60486583 04 YMV  .10143147 05 ZMV  .11187531 05  XM  .12793999 05 YM -.18553517 05  ZM -.90727578 04
XSV  .22922166 05 YSV  .12440482 05 ZSV  .11156902 05  XS -.40795093 04 YS -.20850851 05  ZS -.90421283 04

22 DECEMBER     HR     MIN  - SEC TIME-START  .14400000 05  JULIAN DATE 1290.5000
LAT(DEG)  .44919381 01  LONG(DEG) .24439393 03   V.APO(FPS) .32660590 02  V.PERI(FPS) .39558189 03
ALT(NM)   .69829560 08  APO(NM)    .33126178 09   PERI(NM)   .27346944 03  PERIOD(MIN) .10037455 10
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X   .78078350 00  Y -.36502293 00 Z    .67257349-01   XD  -.35828478-07    YD    .18948245-08 ZD -.25413651-07
R   .86451613 00  A -.25056488 02 D    .44619874 01    V   .43967304-07 BETA    .14304687 03 AZ   .21060647 03
A   .22197884 01  E   .84746683 00 I    .35011919 02 NODE  -.91460785 01     W   -.19199434 03  M -.23695317 00
R   .16373412-03  V   .62863913-04 G  -.32023719-01    S    .26997926 03  SVE    .60788127 02  F   .24138343 03
ELK  .15869394 03 MLK   .10489273 03 SLK   .13725426 03   RM   .11131509 05 RS   .24695554 05          ELLIPSE
ETA  .24170888 00 ZTA -.37596767 00 RHO   .18910166 05   XP   .72287717 04           VEHICLE IS NOT ECLIPSED
XMV  .26823062 04 YMV   .61910333 04 ZMV   .88536338 04   XM   .15630862 05 YM -.14752595 05  ZM -.72761220 04
XSV  .18311127 05 YSV   .12604534 05 ZSV   .10756359 05   XS   .20410156-01 YS -.21166095 05  ZS -.91788470 04

 1 JANUARY        HR      MIN  - SEC TIME-START  .28800000 05  JULIAN DATE 1300.5000
LAT(DEG)  .31342939 01  LONG(DEG) .23376169 03   V.APO(FPS) .32787661 02  V.PERI(FPS) .39561923 03
ALT(NM)   .66356944 08  APO(NM)   .32985130 09   PERI(NM)    .27333866 08  PERIOD(MIN) .99777473 09
X   .73833997 00  Y -.35744681 00 Z    .44618313-01   XD  -.64289309-07    YD    .13847836-07 ZD -.28303476-07
R   .82152597 00  A -.25832656 02 D    .31133519 01    V   .71595841-07 BETA    .15587411 03 AZ   .21209691 03
A   .22109767 01  E   .84693215 00 I    .35005282 02 NODE  -.91624267 01     W   -.19192925 03  M -.18614140 00
R   .15559204-03  V   .59833788-04 G  -.62570307-01    S    .26997626 03  SVE    .70216740 02  F   .24967256 03
ELK  .15790104 03 MLK   .92756180 02 SLK   .12891342 03   RM   .68259059 04 RS   .20771949 05          ELLIPSE
ETA  .22482575 00 ZTA -.57565729 00 RHO   .16283019 05   XP   .10225664 05           VEHICLE IS NOT ECLIPSED
XMV  .58425293 02 YMV   .24053182 04 ZMV   .63878026 04   XM   .17259235 05 YM -.10789183 05  ZM -.53412863 04
XSV  .13235932 05 YSV   .12439505 05 ZSV   .10076839 05   XS   .40817281 04 YS -.20823370 05  ZS -.90303226 04

11 JANUARY        HR      MIN  - SEC TIME-START  .43200000 05  JULIAN DATE 1310.5000
LAT(DEG)  .11581376 01  LONG(DEG) .22232342 03   V.APO(FPS) .32685461 02  V.PERI(FPS) .39539648 03
ALT(NM)   .60659320 08  APO(NM)   .33113385 09   PERI(NM)    .27370030 08  PERIOD(MIN) .10033053 10
X   .66651681 00  Y -.34570954 00 Z    .15077399-01   XD  -.10359580-06    YD    .94189571-08 ZD -.42779643-07
R   .75099072 00  A -.27414907 02 D    .11503863 01    V   .11247624-06 BETA    .14972655 03 AZ   .22392807 03
A   .22191394 01  E   .84729344 00 I    .35003970 02 NODE  -.91650341 01     W   -.19201510 03  M -.13304701 00
R   .14223309-03  V   .54791481-04 G  -.10157768 00    S    .26995729 03  SVE    .84728897 02  F   .26217407 03
ELK  .15616412 03 MLK   .66631162 02 SLK   .11649990 03   RM   .44652258 04 RS   .16597758 05          ELLIPSE
ETA  .20295912 00 ZTA -.79257864 00 RHO   .12563185 05   XP   .12286881 05           VEHICLE IS NOT ECLIPSED
XMV -.21048428 04 YMV -.11477593 04 ZMV   .37670315 04   XM   .17737901 05 YM -.69608096 04  ZM -.34133932 04
XSV  .75984731 04 YSV   .11727830 05 ZSV   .89558425 04   XS   .80345854 04 YS -.19836399 05  ZS -.86022042 04

21 JANUARY        HR      MIN  - SEC TIME-START  .57600000 05  JULIAN DATE 1320.5000
LAT(DEG) -.31711928 01  LONG(DEG) .20767685 03   V.APO(FPS) .32657949 02  V.PERI(FPS) .39556202 03
ALT(NM)   .53369792 08  APO(NM)   .33130598 09   PERI(NM)    .27349756 08  PERIOD(MIN) .10039428 10
X   .55824281 00  Y -.35161727 00 Z   -.36308287-01   XD  -.14531730-06    YD   -.32214524-07 ZD -.82069325-07
R   .66074808 00  A -.32205364 02 D   -.31500052 01    V   .16997138-06 BETA    .12650752 03 AZ   .23003213 03
A   .22200794 01  E   .84747115 00 I    .35006052 02 NODE  -.91509025 01     W    .16801859 03  M -.80951512-01
R   .12514168-03  V   .48214601-04 G  -.12016658 00    S    .26989571 03  SVE    .11174856 03  F -.76845554 02
ELK  .15067717 03 MLK   .53638688 02 SLK   .95474260 02   RM   .63161764 04 RS   .12300983 05          ELLIPSE
```

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ETA  .16201432 00 ZTA -.10767597 01 RHO  .76076268 04  XP  .13465939 05                VEHICLE IS NOT ECLIPSED
XMV -.41184043 04 YMV -.47262280 04 ZMV  .77175124 03  XM  .17211911 05 YM -.35209059 04  ZM -.16233570 04
XSV  .13534241 04 YSV  .99853614 04 ZSV  .70551396 04  XS  .11740083 05 YS -.18232495 05  ZS -.79067454 04

31 JANUARY       HR    MIN  - SEC TIME-START  .72000000 05  JULIAN DATE 1330.5000
LAT(DEG) -.13118786 02  LONG(DEG) .18556253 03   V.APO(FPS) .32875041 02  V.PERI(FPS) .39548554 03
ALT(NM)   .50180542 08  APO(NM)   .32900937 09   PERI(NM)   .27345931 08  PERIOD(MIN) .99429952 09
X  .43197154 00  Y -.42395779 00 Z   -.14011327 00    XD  -.12235577-06    YD  -.14950751-06 ZD -.16510019-06
R  .62126592 00  A -.44463575 02 D   -.13033967 02    V    .25412891-06 BETA   .77688929 02 AZ  .23080020 03
A  .22058399 01  E  .84650799 00 I    .35008303 02 NODE -.91625519 01    W     .16805753 03  M -.29266119-01
R  .11766400-03  V  .44328904-04 G    .70034966-01    S    .26979717 03  SVE   .16646691 03  F -.35647520 02
ELK  .13616147 03 MLK  .61949761 02 SLK  .54246841 02  RM  .11376696 05 RS  .86876107 04         ELLIPSE
ETA  .64636774-01 ZTA -.15109076 01 RHO  .12133824 04  XP  .14515207 05                VEHICLE IS NOT ECLIPSED
XMV -.57590347 04 YMV -.92731571 04 ZMV -.32048853 04  XM  .15890867 05 YM -.67071350 03  ZM -.81451904 02
XSV -.49478387 04 YSV  .61197859 04 ZSV  .36799041 04  XS  .15079671 05 YS -.16063656 05  ZS -.69662413 04

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LAT(DEG) -.23024971 02  LONG(DEG) .16462807 03   V.APO(FPS) .32746901 02  V.PERI(FPS) .39553562 03
ALT(NM)   .63949390 08  APO(NM)   .33035777 09   PERI(NM)   .27347585 08  PERIOD(MIN) .99995515 09
X  .41269100 00  Y -.60141530 00 Z   -.30790894 00    XD   .99229851-07    YD  -.22573044-06 ZD -.19608138-06
R  .79172099 00  A -.55542097 02 D   -.22886750 02    V    .31503762-06 BETA   .18096473 02 AZ  .20797246 03
A  .22141967 01  E  .84707804 00 I    .35005389 02 NODE -.91632613 01    W     .16802156 03  M  .23134738-01
R  .14994716-03  V  .53234912-04 G    .32229905 00    S    .26990698 03  SVE   .11254080 03  F  .28948493 02
ELK  .12282653 03 MLK  .77636017 02 SLK  .10312652 02  RM  .18196813 05 RS  .84245266 04         ELLIPSE
ETA -.54606942-01 ZTA  .43737540 01 RHO  .61600896 04  XP  .17489005 05                VEHICLE IS NOT ECLIPSED
XMV -.43624642 04 YMV -.15566098 05 ZMV -.83540110 04  XM  .14042074 05 YM  .14599856 04  ZM  .11320499 04
XSV -.82756097 04 YSV -.70518945 03 ZSV -.14105466 04  XS  .17955219 05 YS -.13400922 05  ZS -.58114145 04

20 FEBRUARY      HR    MIN  - SEC TIME-START  .10080000 06  JULIAN DATE 1350.5000
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ALT(NM)   .84740144 08  APO(NM)   .33253731 09   PERI(NM)   .27359931 08  PERIOD(MIN) .10091601 10
X  .56956414 00  Y -.76031426 00 Z   -.44513088 00    XD   .23186602-06    YD  -.13359895-06 ZD -.11899698-06
R  .10491056 01  A -.53162505 02 D   -.25106084 02    V    .29286654-06 BETA   .21120230 02 AZ  .91848344 02
A  .22277642 01  E  .84794076 00 I    .35003630 02 NODE -.91631700 01    W     .16808575 03  M  .74609756-01
R  .19869424-03  V  .69169432-04 G    .22629761 00    S    .26999718 03  SVE   .69121811 02  F  .73444925 02
ELK  .12398985 03 MLK  .94527799 02 SLK  .54873330 02  RM  .24146874 05 RS  .11825456 05         ELLIPSE
ETA -.10110245 00 ZTA  .42254012 01 RHO  .11620676 05  XP  .21634972 05                VEHICLE IS NOT ECLIPSED
XMV  .14067395 04 YMV -.20662342 05 ZMV -.12416128 05  XM  .11952308 05 YM  .28292773 04  ZM  .19756455 04
XSV -.69211140 04 YSV -.75087184 04 ZSV -.59631141 04  XS  .20280161 05 YS -.10324346 05  ZS -.44773686 04

1 MARCH          HR    MIN  - SEC TIME-START  .11520000 06  JULIAN DATE 1360.5000
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LAT(DEG) -.24616035 02  LONG(DEG) .15338503 03   V.APO(FPS) .32718811 02  V.PERI(FPS) .39549508 03
ALT(NM)   .10141989 09  APO(NM)   .33069439 09   PERI(NM)   .27354773 08  PERIOD(MIN) .10013971 10
X   .77833117 00  Y -.83679084 00 Z  -.52010149 00   XD   .24096738-06   YD  -.49163268-07 ZD -.59404943-07
R   .12555970 01  A -.47072927 02 D  -.24470611 02   V    .25300445-06 BETA   .35198550 02 AZ  .78600761 02
A   .22163248 01  E  .84718472 00 I   .35006163 02 NODE  -.91496693 01   W    .16803870 03  M   .12737653 00
R   .23780246-03  V  .83192436-04 G   .14238811 00   S   -.89980148 02  SVE   .51828714 02  F   .96037863 02
ELK  .12924321 03 MLK  .10799189 03 SLK  .77430280 02  RM  .28595635 05 RS  .16109358 05        ELLIPSE
ETA -.11513280 00 ZTA  .41465878 01 RHO  .15928123 05  XP  .24695782 05          VEHICLE IS NOT ECLIPSED
XMV  .83543502 04 YMV -.23097377 05 ZMV -.14643304 05  XM  .99012985 04 YM  .34705652 04  ZM  .24443960 04
XSV -.37283108 04 YSV -.12693218 05 ZSV -.91920242 04  XS  .21983959 05 YS -.69335935 04  ZS -.30068835 04

11 MARCH       HR     MIN   - SEC TIME-START  .12960000 06   JULIAN DATE 1370.5000
LAT(DEG) -.23286492 02  LONG(DEG) .14941889 03   V.APO(FPS) .32697983 02  V.PERI(FPS) .39572734 03
ALT(NM)   .11394170 09  APO(NM)   .33074173 09   PERI(NM)   .27325221 08  PERIOD(MIN) .10014717 10
X   .97617993 00  Y -.85406820 00 Z  -.55450173 00   XD   .21412418-06   YD   .50007098-08 ZD -.23172222-07
R   .14106140 01  A -.41182958 02 D  -.23147058 02   V    .21543241-06 BETA   .44270695 02 AZ  .74279042 02
A   .22164349 01  E  .84735738 00 I   .35006737 02 NODE  -.91706163 01   W   -.19199655 03  M   .17946717 00
R   .26716174-03  V  .94438344-04 G   .93590374-01   S   -.89975277 02  SVE   .44176203 02  F   .10916821 03
ELK  .13458078 03 MLK  .11844942 03 SLK  .90508206 02  RM  .31841780 05 RS  .20310090 05        ELLIPSE
ETA -.12004282 00 ZTA  .40693736 01 RHO  .19967055 05  XP  .26287692 05          VEHICLE IS NOT ECLIPSED
XMV  .14752430 05 YMV -.23528728 05 ZMV -.15577668 05  XM  .81437340 04 YM  .34966777 04  ZM  .25719073 04
XSV -.12741626 03 YSV -.16698668 05 ZSV -.11560191 05  XS  .23023580 05 YS -.33333823 04  ZS -.14455697 04

21 MARCH       HR     MIN   - SEC TIME-START  .14400000 06   JULIAN DATE 1380.5000
LAT(DEG) -.21839666 02  LONG(DEG) .14468847 03   V.APO(FPS) .32611528 02  V.PERI(FPS) .39540285 03
ALT(NM)   .12319127 09  APO(NM)   .33193695 09   PERI(NM)   .27373909 08  PERIOD(MIN) .10066948 10
X   .11455202 01  Y -.83401954 00 Z  -.56408406 00   XD   .17703130-06   YD   .38622771-07 ZD -.78746680-09
R   .15251216 01  A -.36057260 02 D  -.21707087 02   V    .18119719-06 BETA   .51765903 02 AZ  .72079563 02
A   .22241346 01  E  .84761480 00 I   .35004925 02 NODE  -.91598567 01   W   -.19190602 03  M   .23038322 00
R   .28884879-03  V  .10319176-03 G   .62263722-01   S   -.89975682 02  SVE   .40397529 02  F   .11775352 03
ELK  .13933256 03 MLK  .12668617 03 SLK  .99192859 02  RM  .34027484 05 RS  .24265154 05        ELLIPSE
ETA -.12206069 00 ZTA  .39826650 01 RHO  .23943358 05  XP  .26464225 05          VEHICLE IS NOT ECLIPSED
XMV  .19997300 05 YMV -.22646444 05 ZMV -.15656189 05  XM  .68707153 04 YM  .30846326 04  ZM  .24256759 04
XSV  .34980386 04 YSV -.19931234 05 ZSV -.13390569 05  XS  .23369977 05 YS  .36942236 03  ZS  .16005615 03

31 MARCH       HR     MIN   - SEC TIME-START  .15840000 06   JULIAN DATE 1390.5000
LAT(DEG) -.20467564 02  LONG(DEG) .13918936 03   V.APO(FPS) .32724029 02  V.PERI(FPS) .39550426 03
ALT(NM)   .12974495 09  APO(NM)   .33063055 09   PERI(NM)   .27353219 08  PERIOD(MIN) .10011228 10
X   .12813872 01  Y -.79140890 00 Z  -.55836584 00   XD   .13737372-06   YD   .57986768-07 ZD  .12828677-07
R   .16062545 01  A -.31700260 02 D  -.20341799 02   V    .14966155-06 BETA   .59232661 02 AZ  .70906325 02
A   .22159200 01  E  .84716549 00 I   .35002626 02 NODE  -.91465709 01   W   -.19197811 03  M   .28391591 00
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R   .30421487-03  V   .10970380-03 G    .39984805-01    S   -.89978029 02  SVE    .38371452 02   F   .12412767 03
ELK  .14341194 03 MLK  .13315030 03 SLK  .10550581 03  RM   .35228706 05 RS   .27963859 05             ELLIPSE
ETA -.12320752 00 ZTA  .38854142 01 RHO  .27781994 05  XP   .25316204 05            VEHICLE IS NOT ECLIPSED
XMV  .23852925 05 YMV -.21007537 05 ZMV -.15191547 05  XM   .62018325 04 YM   .24451516 04   ZM  .20951547 04
XSV  .70366023 04 YSV -.22621706 05 ZSV -.14856718 05  XS   .23018155 05 YS   .40593210 04   ZS  .17603257 04

10 APRIL        HR     MIN   - SEC TIME-START  .17280000 06  JULIAN DATE 1400.5000
LAT(DEG) -.19252459 02  LONG(DEG) .13298516 03   V.APO(FPS) .32651668 02  V.PERI(FPS) .39581780 03
ALT(NM)   .13398616 09  APO(NM)   .33117676 09   PERI(NM)    .27316162 08  PERIOD(MIN) .10032593 10
X   .13830684 01  Y -.73689904 00 Z   -.54367766 00    XD    .98252952-07    YD    .66612453-07 ZD  .20293927-07
R   .16587597 01  A -.28048697 02 D   -.19132966 02     V    .12042718-06 BETA    .67709151 02 AZ  .70427762 02
A   .22190716 01  E  .84758929 00 I    .35011303 02 NODE   -.91796464 01     W  -.19197707 03  M   .33517113 00
R   .31415904-03  V  .11417220-03 G    .22923468-01     S  -.89981266 02  SVE    .37166055 02  F   .12902480 03
ELK  .14682813 03 MLK  .13802618 03 SLK  .11037688 03  RM   .35537249 05 RS   .31430455 05             ELLIPSE
ETA -.12427606 00 ZTA  .37777928 01 RHO  .31317528 05  XP   .22937449 05            VEHICLE IS NOT ECLIPSED
XMV  .26263073 05 YMV -.19096779 05 ZMV -.14438148 05  XM   .61766028 04 YM   .18129145 04   ZM  .16862645 04
XSV  .10451815 05 YSV -.24913682 05 ZSV -.16060558 05  XS   .21987861 05 YS   .76298181 04   ZS  .33086749 04

20 APRIL        HR     MIN   - SEC TIME-START  .18720000 06  JULIAN DATE 1410.5000
LAT(DEG) -.18240157 02  LONG(DEG) .12612037 03   V.APO(FPS) .32651775 02  V.PERI(FPS) .39525148 03
ALT(NM)   .13621307 09  APO(NM)   .33161389 09   PERI(NM)    .27391507 08  PERIOD(MIN) .10054113 10
X   .14518091 01  Y -.67876051 00 Z   -.52463129 00    XD    .61340041-07    YD    .66684754-07 ZD  .23113678-07
R   .16863284 01  A -.25057376 02 D   -.18126053 02     V    .93507748-07 BETA    .78415590 02 AZ  .70573133 02
A   .22222438 01  E  .84738711 00 I    .35001308 02 NODE   -.91489624 01     W  -.19190941 03  M   .38652068 00
R   .31938038-03  V  .11678020-03 G    .92123859-02     S  -.89985050 02  SVE    .36281878 02  F   .13286169 03
ELK  .14959467 03 MLK  .14134051 03 SLK  .11430656 03  RM   .35094347 05 RS   .34692625 05             ELLIPSE
ETA -.12561457 00 ZTA  .36598891 01 RHO  .34354040 05  XP   .19440011 05            VEHICLE IS NOT ECLIPSED
XMV  .27310331 05 YMV -.17333446 05 ZMV -.13612885 05  XM   .67416479 04 YM   .14132131 04   ZM  .13077317 04
XSV  .13741183 05 YSV -.26898298 05 ZSV -.17065748 05  XS   .20310796 05 YS   .10978065 05   ZS  .47605944 04

30 APRIL        HR     MIN   - SEC TIME-START  .20160000 06  JULIAN DATE 1420.5000
LAT(DEG) -.17464312 02  LONG(DEG) .11860887 03   V.APO(FPS) .32716269 02  V.PERI(FPS) .39564534 03
ALT(NM)   .13669692 09  APO(NM)   .33060527 09   PERI(NM)    .27334818 08  PERIOD(MIN) .10009396 10
X   .14900186 01  Y -.62367857 00 Z   -.50478780 00    XD    .27733715-07    YD    .59766612-07 ZD  .22277971-07
R   .16923183 01  A -.22712771 02 D   -.17354435 02     V    .69552245-07 BETA    .93505539 02 AZ  .71514361 02
A   .22156496 01  E  .84724966 00 I    .35003407 02 NODE   -.91537435 01     W  -.19199615 03  M   .44046482 00
R   .32051482-03  V  .11772226-03 G   -.20696575-02     S  -.89989285 02  SVE    .35418855 02  F   .13622406 03
ELK  .15171210 03 MLK  .14300256 03 SLK  .11757827 03  RM   .34102269 05 RS   .37769256 05             ELLIPSE
ETA -.12737715 00 ZTA  .35316288 01 RHO  .36691304 05  XP   .14969911 05            VEHICLE IS NOT ECLIPSED
XMV  .27175993 05 YMV -.16064380 05 ZMV -.12898289 05  XM   .77721855 04 YM   .14360859 04   ZM  .10585614 04
XSV  .16904869 05 YSV -.28633255 05 ZSV -.17913090 05  XS   .18043309 05 YS   .14004962 05   ZS  .60733627 04
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10 MAY          HR     MIN  - SEC TIME-START  .21600000 06  JULIAN DATE 1430.5000
LAT(DEG) -.16955144 02  LONG(DEG) .11043293 03   V.APO(FPS) .32629667 02  V.PERI(FPS) .39575567 03
ALT(NM)   .13571608 09  APO(NM)    .33146437 09   PERI(NM)    .27325684 08  PERIOD(MIN) .10045069 10
X  .15009223 01  Y -.57713015 00 Z   -.48697393 00   XD  -.17489462-08    YD    .47127157-07 ZD  .18524868-07
R  .16801757 01  A -.21032600 02 D   -.16848084 02    V    .50667528-07 BETA    .11714837 03 AZ  .74096315 02
A  .22209108 01  E  .84766243 00 I    .35013839 02 NODE  -.91797582 01     W  -.19194929 03  M  .49058253 00
R  .31821510-03  V  .11721800-03 G  -.11300381-01     S  -.89993959 02  SVE   .34365933 02  F  .13898579 03
ELK  .15316661 03 MLK  .14284421 03 SLK  .12036556 03  RM  .32858526 05 RS  .40682733 05        ELLIPSE
ETA -.12960895 00 ZTA  .33922245 01 RHO  .38151795 05  XP  .96919121 04          VEHICLE IS NOT ECLIPSED
XMV  .26125358 05 YMV -.15565436 05 ZMV -.12444504 05  XM  .90785652 04 YM  .20289293 04  ZM  .10225983 04
XSV  .19947173 05 YSV -.30166091 05 ZSV -.18633359 05  XS  .15256750 05 YS  .16629584 05  ZS  .72114535 04

20 MAY          HR     MIN  - SEC TIME-START  .23040000 06  JULIAN DATE 1440.5000
LAT(DEG) -.16741632 02  LONG(DEG) .10154665 03   V.APO(FPS) .32685396 02  V.PERI(FPS) .39514509 03
ALT(NM)   .13358046 09  APO(NM)    .33132914 09   PERI(NM)    .27403543 08  PERIOD(MIN) .10042559 10
X  .14883657 01  Y -.54356826 00 Z   -.47344264 00   XD  -.26483072-07    YD    .29882678-07 ZD  .12457414-07
R  .16537372 01  A -.20062774 02 D   -.16635764 02    V    .41827200-07 BETA    .15286466 03 AZ  .84345859 02
A  .22205557 01  E  .84720399 00 I    .34995842 02 NODE  -.91399035 01     W  -.19192330 03  M  .54304263 00
R  .31320781-03  V  .11552655-03 G  -.18461051-01     S  -.89999066 02  SVE   .32941778 02  F  .14135310 03
ELK  .15393091 03 MLK  .14073223 03 SLK  .12279149 03  RM  .31765652 05 RS  .43449671 05        ELLIPSE
ETA -.13226555 00 ZTA  .32405120 01 RHO  .38583189 05  XP  .37971909 04          VEHICLE IS NOT ECLIPSED
XMV  .24488297 05 YMV -.16018333 05 ZMV -.12360947 05  XM  .10421113 05 YM  .32690154 04  ZM  .12564156 04
XSV  .22878810 05 YSV -.31527183 05 ZSV -.19247615 05  XS  .12030599 05 YS  .18777865 05  ZS  .81430839 04

30 MAY          HR     MIN  - SEC TIME-START  .24480000 06  JULIAN DATE 1450.5000
LAT(DEG) -.16849551 02  LONG(DEG) .91880582 02   V.APO(FPS) .32689988 02  V.PERI(FPS) .39586931 03
ALT(NM)   .13065075 09  APO(NM)    .33071920 09   PERI(NM)    .27306881 08  PERIOD(MIN) .10013003 10
X  .14566607 01  Y -.52651980 00 Z   -.46596122 00   XD  -.46009608-07    YD    .90711686-08 ZD  .46048823-08
R  .16174681 01  A -.19872730 02 D   -.16743079 02    V    .47120855-07 BETA    .16596803 03 AZ  .21848004 03
A  .22161819 01  E  .84744240 00 I    .35009634 02 NODE  -.91674797 01     W  -.19200289 03  M  .59664708 00
R  .30633866-03  V  .11295497-03 G  -.23188638-01     S   .26999546 03  SVE   .30995898 02  F  .14359669 03
ELK  .15396394 03 MLK  .13676108 03 SLK  .12493291 03  RM  .31303674 05 RS  .46080196 05        ELLIPSE
ETA -.13519891 00 ZTA  .30752307 01 RHO  .37866102 05  XP -.24928011 04          VEHICLE IS NOT ECLIPSED
XMV  .22619588 05 YMV -.17510502 05 ZMV -.12714426 05  XM  .11546185 05 YM  .51610535 04  ZM  .17853705 04
XSV  .25702346 05 YSV -.32739400 05 ZSV -.19771330 05  XS  .84634260 04 YS  .20389952 05  ZS  .88422750 04

9 JUNE          HR     MIN  - SEC TIME-START  .25920000 06  JULIAN DATE 1460.5000
LAT(DEG) -.17294770 02  LONG(DEG) .81351421 02   V.APO(FPS) .32633651 02  V.PERI(FPS) .39554407 03
ALT(NM)   .12735437 09  APO(NM)    .33158539 09   PERI(NM)    .27353695 08  PERIOD(MIN) .10051327 10
X  .14104538 01  Y -.52863204 00 Z   -.46585840 00   XD  -.60010280-07    YD   -.14306649-07 ZD -.45438250-08
R  .15766597 01  A -.20545782 02 D   -.17185827 02    V    .61859198-07 BETA    .14022810 03 AZ  .24054320 03
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A   .22218332 01   E   .84756960 00 I    .35010631 02 NODE  -.91700418 01     W   -.19192540 03  M   .64608130 00
R   .29860979-03   V   .10987299-03 G   -.24793568-01    S    .26998985 03  SVE    .28394741 02  F   .14543451 03
ELK  .15321249 03 MLK  .13153749 03 SLK  .12684612 03  RM   .31950759 05 RS   .48589812 05         ELLIPSE
ETA -.13812201 00 ZTA  .28947394 01 RHO  .35921547 05  XP -.89502272 04             VEHICLE IS NOT ECLIPSED
XMV  .20885429 05 YMV -.20039620 05 ZMV -.13530095 05  XM   .12196568 05 YM   .76406293 04  ZM   .26034514 04
XSV  .28425245 05 YSV -.33825864 05 ZSV -.20218464 05  XS   .46567524 04 YS   .21426873 05  ZS   .92918204 04

19 JUNE          HR     MIN  - SEC TIME-START  .27360000 06  JULIAN DATE 1470.5000
LAT(DEG) -.18071052 02  LONG(DEG) .69881103 02   V.APO(FPS) .32706821 02  V.PERI(FPS) .39514929 03
ALT(NM)    .12419538 09  APO(NM)    .33109226 09   PERI(NM)    .27401610 08  PERIOD(MIN) .10032633 10
X   .13546084 01   Y -.55170231 00 Z   -.47405418 00    XD   -.68302421-07    YD   -.39285027-07 ZD -.14530960-07
R   .15375521 01   A -.22159991 02 D   -.17957862 02     V    .80122922-07 BETA    .12127807 03 AZ  .24516811 03
A   .22190774 01   E   .84711299 00 I    .34992251 02 NODE  -.91369840 01     W   -.19194432 03  M   .69984657 00
R   .29120305-03   V   .10672018-03 G   -.22333971-01    S    .26998455 03  SVE    .25032408 02  F   .14715820 03
ELK  .15162272 03 MLK  .12618669 03 SLK  .12857797 03  RM   .34008801 05 RS   .50986448 05         ELLIPSE
ETA -.14056837 00 ZTA  .26977597 01 RHO  .32711554 05  XP -.15332892 05             VEHICLE IS NOT ECLIPSED
XMV  .19632917 05 YMV -.23504843 05 ZMV -.14787477 05  XM   .12139232 05 YM   .10564743 05  ZM   .36686024 04
XSV  .31055456 05 YSV -.34798117 05 ZSV -.20597758 05  XS   .71669385 03 YS   .21858016 05  ZS   .94788833 04

29 JUNE          HR     MIN  - SEC TIME-START  .28800000 06  JULIAN DATE 1480.5000
LAT(DEG) -.19133491 02  LONG(DEG) .57430279 02   V.APO(FPS) .32655959 02  V.PERI(FPS) .39606633 03
ALT(NM)    .12174989 09  APO(NM)    .33093797 09   PERI(NM)    .27282919 08  PERIOD(MIN) .10021176 10
X   .12940856 01   Y -.59671047 00 Z   -.49108531 00    XD   -.70841586-07    YD   -.64930967-07 ZD -.24923387-07
R   .15072775 01   A -.24754704 02 D   -.19014624 02     V    .99276059-07 BETA    .10577910 03 AZ  .24807957 03
A   .22173877 01   E   .84765915 00 I    .35018487 02 NODE  -.91809553 01     W   -.19199411 03  M   .75225544 00
R   .28546923-03   V   .10400356-03 G   -.14872759-01    S    .26998035 03  SVE    .20878332 02  F   .14882195 03
ELK  .14917103 03 MLK  .12182203 03 SLK  .13015591 03  RM   .37493957 05 RS   .53276578 05         ELLIPSE
ETA -.14188177 00 ZTA  .24841435 01 RHO  .28248583 05  XP -.21387110 05             VEHICLE IS NOT ECLIPSED
XMV  .19158240 05 YMV -.27728977 05 ZMV -.16427491 05  XM   .11194355 05 YM   .13733217 05  ZM   .49091542 04
XSV  .33593852 05 YSV -.35669488 05 ZSV -.20917326 05  XS  -.32412561 04 YS   .21673728 05  ZS   .93989886 04

 9 JULY          HR     MIN  - SEC TIME-START  .30240000 06  JULIAN DATE 1490.5000
LAT(DEG) -.20383840 02  LONG(DEG) .44047333 02   V.APO(FPS) .32656797 02  V.PERI(FPS) .39525797 03
ALT(NM)    .12063361 09  APO(NM)    .33155398 09   PERI(NM)    .27390319 08  PERIOD(MIN) .10051547 10
X   .12338269 01   Y -.66383470 00 Z   -.51711926 00    XD   -.67715221-07    YD   -.90337333-07 ZD -.35306105-07
R   .14934583 01   A -.28281542 02 D   -.20258500 02     V    .11829077-06 BETA    .91726419 02 AZ  .25076650 03
A   .22218655 01   E   .84736775 00 I    .35002091 02 NODE  -.91552242 01     W   -.19191386 03  M   .80199703 00
R   .28285194-03   V   .10227914-03 G   -.19959746-02    S    .26997818 03  SVE    .16009687 02  F   .15017069 03
ELK  .14591516 03 MLK  .11905574 03 SLK  .13160597 03  RM   .42182659 05 RS   .55471493 05         ELLIPSE
ETA -.14129533 00 ZTA  .22552273 01 RHO  .22597798 05  XP -.26869155 05             VEHICLE IS NOT ECLIPSED
XMV  .19699959 05 YMV -.32469879 05 ZMV -.18357432 05  XM   .92392778 04 YM   .16899729 05  ZM   .62284725 04
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XSV  .36048572 05 YSV -.36452633 05 ZSV -.21184724 05  XS -.71093354 04 YS  .20882483 05  ZS  .90557645 04

19 JULY          HR    MIN  - SEC TIME-START  .31680000 06  JULIAN DATE 1500.5000
LAT(DEG) -.21672310 02  LONG(DEG) .29917014 02   V.APO(FPS) .32710252 02  V.PERI(FPS) .39530907 03
ALT(NM)    .12143450 09  APO(NM)    .33093129 09   PERI(NM)    .27380088 08  PERIOD(MIN) .10024973 10
X  .11786455 01  Y -.75249334 00 Z   -.55197787 00   XD  -.59134099-07   YD  -.11463853-05 ZD -.45287507-07
R  .15033732 01  A -.32555751 02 D   -.21540548 02    V   .13671062-06 BETA   .78332447 02 AZ  .25361192 03
A  .22179479 01  E  .84715526 00 I    .34994332 02 NODE  -.91430590 01    W  -.19196670 03  M  .85671249 00
R  .28472976-03  V  .10209903-03 G    .15515354-01    S   .26997880 03  SVE   .10669473 02  F  .15155736 03
ELK  .14204159 03 MLK  .11794999 03 SLK  .13294977 03  RM  .47727375 05 RS  .57573899 05          ELLIPSE
ETA -.13814571 00 ZTA  .20148541 01 RHO  .15916178 05  XP -.31538255 05          VEHICLE IS NOT ECLIPSED
XMV  .21410549 05 YMV -.37431004 05 ZMV -.20455089 05  XM  .62344155 04 YM  .19781378 05  ZM  .75085248 04
XSV  .38423376 05 YSV -.37151966 05 ZSV -.21403959 05  XS -.10778412 05 YS  .19502340 05  ZS  .84573956 04

29 JULY          HR    MIN  - SEC TIME-START  .33120000 06  JULIAN DATE 1510.5000
LAT(DEG) -.22828891 02  LONG(DEG) .15375859 02   V.APO(FPS) .32630412 02  V.PERI(FPS) .39610900 03
ALT(NM)    .12461686 09  APO(NM)    .33118385 09   PERI(NM)    .27278890 08  PERIOD(MIN) .10031326 10
X  .11331186 01  Y -.86137766 00 Z   -.59515528 00   XD  -.45435349-07   YD  -.13702162-06 ZD -.54502298-07
R  .15427699 01  A -.37241483 02 D   -.22691588 02    V   .15430423-06 BETA   .65430983 02 AZ  .25671490 03
A  .22188848 01  E  .84778441 00 I    .35024328 02 NODE  -.91867118 01    W  -.19197235 03  M  .90737355 00
R  .29219128-03  V  .10392842-03 G    .35370398-01    S   .26998222 03  SVE   .54055183 01  F  .15284763 03
ELK  .13787017 03 MLK  .11826477 03 SLK  .13419863 03  RM  .53775022 05 RS  .59589601 05          ELLIPSE
ETA -.13217149 00 ZTA  .17693068 01 RHO  .36938331 04  XP -.35165412 05          VEHICLE IS NOT ECLIPSED
XMV  .24346255 05 YMV -.42296983 05 ZMV -.22582696 05  XM  .22308838 04 YM  .22093490 05  ZM  .86234121 04
XSV  .40719056 05 YSV -.37777781 05 ZSV -.21580508 05  XS -.14141917 05 YS  .17574289 05  ZS  .76212236 04

 8 AUGUST        HR    MIN  - SEC TIME-START  .34560000 06  JULIAN DATE 1520.5000
LAT(DEG) -.23716932 02  LONG(DEG) .85552216 00   V.APO(FPS) .32685241 02  V.PERI(FPS) .39502476 03
ALT(NM)    .13043280 09  APO(NM)    .33142404 09   PERI(NM)    .27419615 08  PERIOD(MIN) .10047320 10
X  .11014758 01  Y -.98849605 00 Z   -.64583947 00   XD  -.27080653-07   YD  -.15672737-06 ZD -.62611003-07
R  .16147700 01  A -.41903713 02 D   -.23575525 02    V   .17092971-06 BETA   .53149549 02 AZ  .26007337 03
A  .22212426 01  E  .84716167 00 I    .34992061 02 NODE  -.91420113 01    W  -.19191753 03  M  .95844597 00
R  .30582765-03  V  .10805678-03 G    .54355547-01    S   .26998749 03  SVE   .29082860 01  F  .15392570 03
ELK  .13379121 03 MLK  .11969414 03 SLK  .13536814 03  RM  .60006962 05 RS  .61526481 05          ELLIPSE
ETA -.12370246 00 ZTA  .15256094 01 RHO  .51457837 04  XP -.37546426 05          VEHICLE IS NOT ECLIPSED
XMV  .28471679 05 YMV -.46747325 05 ZMV -.24594443 05  XM -.26367173 04 YM  .23562289 05  ZM  .94463685 04
XSV  .42943462 05 YSV -.38336315 05 ZSV -.21718516 05  XS -.17108500 05 YS  .15151278 05  ZS  .65704413 04

18 AUGUST        HR    MIN  - SEC TIME-START  .36000000 06  JULIAN DATE 1530.5000
LAT(DEG) -.24274617 02  LONG(DEG)-.13224059 02   V.APO(FPS) .32693369 02  V.PERI(FPS) .39562469 03
ALT(NM)    .13888759 09  APO(NM)    .33087125 09   PERI(NM)    .27339157 08  PERIOD(MIN) .10020736 10
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X   .10875001 01  Y -.11312325 01 Z   -.70293999 00   XD  -.46419785-08    YD  -.17306893-06 ZD -.69307942-07
R   .17194383 01  A -.46129184 02 D   -.24130702 02    V   .18648858-06 BETA   .41689620 02 AZ   .26372360 03
A   .22173229 01  E  .84734069 00 I    .35003166 02 NODE  -.91564918 01    W  -.19198469 03  M   .10133219 01
R   .32565120-03  V  .11454956-03 G    .69656606-01    S   .26999321 03  SVE   .63997719 01  F   .15510514 03
ELK  .13016219 03 MLK  .12195201 03 SLK  .13646857 03  RM  .66140586 05 RS  .63384415 05          ELLIPSE
ETA -.11355985 00 ZTA  .12900990 01 RHO  .12182366 05  XP -.38501206 05          VEHICLE IS NOT ECLIPSED
XMV  .33646445 05 YMV -.50481015 05 ZMV -.26346936 05  XM -.81392820 04 YM  .23948114 05  ZM  .98595767 04
XSV  .45096732 05 YSV -.38829781 05 ZSV -.21820103 05  XS -.19589570 05 YS  .12296881 05  ZS  .53327444 04

28 AUGUST        HR     MIN  - SEC TIME-START  .37440000 06  JULIAN DATE 1540.5000
LAT(DEG) -.24515834 02  LONG(DEG)-.26561096 02   V.APO(FPS) .32625851 02  V.PERI(FPS) .39593360 03
ALT(NM)   .14977334 09  APO(NM)   .33136923 09   PERI(NM)   .27302437 08  PERIOD(MIN) .10040097 10
X   .10944348 01  Y -.12864163 01 Z   -.76511960 00   XD   .21201170-07    YD  -.18544857-06 ZD -.74327257-07
R   .18542012 01  A -.49610109 02 D   -.24370851 02    V   .20091093-06 BETA   .31203463 02 AZ   .26793486 03
A   .22201780 01  E  .84774177 00 I    .35022257 02 NODE  -.91813242 01    W  -.19194708 03  M   .10623991 01
R   .35117448-03  V  .12326545-03 G    .79875882-01    S   .26999825 03  SVE   .10279282 02  F   .15612478 03
ELK  .12722633 03 MLK  .12480381 03 SLK  .13750546 03  RM  .71940070 05 RS  .65169720 05          ELLIPSE
ETA -.10272884 00 ZTA  .10670496 01 RHO  .21528668 05  XP -.37886907 05          VEHICLE IS NOT ECLIPSED
XMV  .39643650 05 YMV -.53250850 05 ZMV -.27714650 05  XM -.13973836 05 YM  .23078136 05  ZM  .97688765 04
XSV  .47181012 05 YSV -.39266936 05 ZSV -.21889546 05  XS -.21511198 05 YS  .90942227 04  ZS  .39437732 04

 7 SEPTEMBER     HR     MIN  - SEC TIME-START  .38880000 06  JULIAN DATE 1550.5000
LAT(DEG) -.24498600 02  LONG(DEG)-.39010919 02   V.APO(FPS) .32707494 02  V.PERI(FPS) .39492823 03
ALT(NM)   .16274406 09  APO(NM)   .33125608 09   PERI(NM)   .27431082 08  PERIOD(MIN) .10040748 10
X   .11248913 01  Y -.14504010 01 Z   -.83082960 00   XD   .49663806-07    YD  -.19336437-06 ZD -.77445860-07
R   .20147758 01  A -.52203824 02 D   -.24353693 02    V   .21413578-06 BETA   .21769677 02 AZ  -.86386966 02
A   .22202739 01  E  .84703105 00 I    .34986072 02 NODE  -.91364602 01    W  -.19193152 03  M   .11153557 01
R   .38158632-03  V  .13392584-03 G    .85077803-01    S  -.89997858 02  SVE   .13434675 02  F   .15705674 03
ELK  .12509106 03 MLK  .12806916 03 SLK  .13848974 03  RM  .77201329 05 RS  .66886851 05          ELLIPSE
ETA -.92044779-01 ZTA  .85796228 00 RHO  .31243563 05  XP -.35598587 05          VEHICLE IS NOT ECLIPSED
XMV  .46168120 05 YMV -.54870964 05 ZMV -.28595930 05  XM -.19783951 05 YM  .20852012 05  ZM  .91089382 04
XSV  .49202658 05 YSV -.39649456 05 ZSV -.21928748 05  XS -.22818489 05 YS  .56305034 04  ZS  .24417559 04

17 SEPTEMBER     HR     MIN  - SEC TIME-START  .40320000 06  JULIAN DATE 1560.5000
LAT(DEG) -.24290062 02  LONG(DEG)-.50561944 02   V.APO(FPS) .32661957 02  V.PERI(FPS) .39600668 03
ALT(NM)   .17739136 09  APO(NM)   .33091861 09   PERI(NM)   .27290444 08  PERIOD(MIN) .10020679 10
X   .11807608 01  Y -.16191522 01 Z   -.89834883 00   XD   .79878997-07    YD  -.19642942-06 ZD -.78491768-07
R   .21961058 01  A -.53898737 02 D   -.24146079 02    V   .22611088-06 BETA   .13481822 02 AZ  -.76225325 02
A   .22173144 01  E  .84761210 00 I    .35016565 02 NODE  -.91726268 01    W  -.19199156 03  M   .11693571 01
R   .41592912-03  V  .14618232-03 G    .86181661-01    S  -.89995079 02  SVE   .15762538 02  F   .15808218 03
ELK  .12375537 03 MLK  .13159890 03 SLK  .13942552 03  RM  .81750006 05 RS  .68534964 05          ELLIPSE
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ETA -.82052593-01 ZTA  .66259139 00 RHO  .40838949 05  XP -.31579988 05          VEHICLE IS NOT ECLIPSED
XMV  .52866397 05 YMV -.55241370 05 ZMV -.28924014 05  XM -.25171818 05 YM  .17264381 05  ZM  .78533679 04
XSV  .51159613 05 YSV -.39979982 05 ZSV -.21939378 05  XS -.23465034 05 YS  .20029932 04  ZS  .86873193 03

27 SEPTEMBER    HR    MIN  - SEC TIME-START  .41760000 06  JULIAN DATE 1570.5000
LAT(DEG) -.23945942 02  LONG(DEG) .29871508 03   V.APO(FPS) .32643191 02  V.PERI(FPS) .39559344 03
ALT(NM)   .19329897 09  APO(NM)   .33144287 09   PERI(NM)   .27346518 08  PERIOD(MIN) .10045040 10
X  .12631580 01  Y -.17883597 01 Z  -.96583309 00   XD   .11091175-06   YD  -.19439045-06 ZD -.77351252-07
R  .23930383 01  A -.54765593 02 D  -.23803499 02   V    .23679586-06 BETA   .69919177 01 AZ -.48401606 02
A  .22209067 01  E  .84754601 00 I   .35011726 02 NODE  -.91674281 01    W  -.19192921 03  M  .12178232 01
R  .45322695-03  V  .15968073-03 G   .84333892-01   S   -.89993133 02  SVE   .17309061 02  F  .15890681 03
ELK  .12315368 03 MLK  .13527129 03 SLK  .14031676 03  RM  .85452240 05 RS  .70120811 05         ELLIPSE
ETA -.73020941-01 ZTA  .47970835 00 RHO  .49948237 05  XP -.25835364 05          VEHICLE IS NOT ECLIPSED
XMV  .59369022 05 YMV -.54361198 05 ZMV -.28675161 05  XM -.29741827 05 YM  .12415471 05  ZM  .60216807 04
XSV  .53055929 05 YSV -.40265378 05 ZSV -.21924779 05  XS -.23428735 05 YS -.16803491 04  ZS -.72870093 03

7 OCTOBER       HR    MIN  - SEC TIME-START  .43200000 06  JULIAN DATE 1580.5000
LAT(DEG) -.23504832 02  LONG(DEG) .28871243 03   V.APO(FPS) .32714627 02  V.PERI(FPS) .39501615 03
ALT(NM)   .21007079 09  APO(NM)   .33111025 09   PERI(NM)   .27418881 08  PERIOD(MIN) .10034113 10
X  .13723640 01  Y -.19535560 01 Z  -.10313669 01   XD   .14176921-06   YD  -.18713809-06 ZD -.73973863-07
R  .26006694 01  A -.54912138 02 D  -.23364393 02   V    .24615302-06 BETA   .61837578 01 AZ  .18544345 02
A  .22192957 01  E  .84703169 00 I   .34986158 02 NODE  -.91386727 01    W  -.19195082 03  M  .12724424 01
R  .49255103-03  V  .17408499-03 G   .80544187-01   S   -.89991725 02  SVE   .18169150 02  F  .15975927 03
ELK  .12319243 03 MLK  .13898380 03 SLK  .14117116 03  RM  .88203069 05 RS  .71645399 05         ELLIPSE
ETA -.65023606-01 ZTA  .30735780 00 RHO  .58236803 05  XP -.18415518 05          VEHICLE IS NOT ECLIPSED
XMV  .65314522 05 YMV -.52318517 05 ZMV -.27866961 05  XM -.33125917 05 YM  .64981343 04  ZM  .36763936 04
XSV  .54895165 05 YSV -.40504489 05 ZSV -.21885395 05  XS -.22706561 05 YS -.53158936 04  ZS -.23051726 04

17 OCTOBER      HR    MIN  - SEC TIME-START  .44640000 06  JULIAN DATE 1590.5000
LAT(DEG) -.22990348 02  LONG(DEG) .27931470 03   V.APO(FPS) .32629612 02  V.PERI(FPS) .39629525 03
ALT(NM)   .22734121 09  APO(NM)   .33104877 09   PERI(NM)   .27254277 08  PERIOD(MIN) .10024624 10
X  .15077930 01  Y -.21102436 01 Z  -.10930196 01   XD   .17143832-06   YD  -.17471616-06 ZD -.68376090-07
R  .28144732 01  A -.54453763 02 D  -.22852288 02   V    .25414981-06 BETA   .11097082 02 AZ  .50817765 02
A  .22178963 01  E  .84785395 00 I   .35028597 02 NODE  -.91844190 01    W  -.19198412 03  M  .13246677 01
R  .53304417-03  V  .18908783-03 G   .75570455-01   S   -.89990634 02  SVE   .18440932 02  F  .16064848 03
ELK  .12377324 03 MLK  .14263786 03 SLK  .14198960 03  RM  .89935120 05 RS  .73108943 05         ELLIPSE
ETA -.58021856-01 ZTA  .14374969 00 RHO  .65377444 05  XP -.94407977 04          VEHICLE IS NOT ECLIPSED
XMV  .70374684 05 YMV -.49297123 05 ZMV -.26561687 05  XM -.35009611 05 YM -.19834570 03  ZM  .92506494 03
XSV  .56675066 05 YSV -.40701427 05 ZSV -.21823117 05  XS -.21309992 05 YS -.87940420 04  ZS -.38135056 04

27 OCTOBER      HR    MIN  - SEC TIME-START  .46080000 06  JULIAN DATE 1600.5000
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LAT(DEG) -.22415608 02  LONG(DEG) .27041368 03   V.APO(FPS) .32673870 02  V.PERI(FPS) .39519981 03
ALT(NM)    .24477639 09  APO(NM)     .33141256 09  PERI(NM)    .27396982 08  PERIOD(MIN) .10045887 10
X  .16679795 01  Y -.22540359 01 Z  -.11489063 01   XD   .19891445-06   YD  -.15733788-06 ZD -.60647945-07
R  .30303167 01  A -.53498675 02 D  -.22280259 02    V   .26076874-06 BETA   .16894069 02 AZ  .61040685 02
A  .22210314 01  E  .84727329 00 I   .34997021 02 NODE  -.91516485 01     W  -.19192319 03  M  .13739175 01
R  .57392362-03  V  .20441018-03 G   .69938465-01    S  -.89989714 02  SVE   .18220597 02  F  .16134720 03
ELK  .12480438 03 MLK  .14614126 03 SLK  .14277608 03  RM  .90627116 05 RS  .74517728 05          ELLIPSE
ETA -.51923331-01 ZTA -.12645864-01 RHO  .71064809 05  XP  .89757782 03          VEHICLE IS NOT ECLIPSED
XMV  .74295559 05 YMV -.45556648 05 ZMV -.24860328 05  XM -.35173333 05 YM -.73114492 04  ZM -.20871099 04
XSV  .58401057 05 YSV -.40860388 05 ZSV -.21740219 05  XS -.19278831 05 YS -.12007709 05  ZS -.52072185 04

 6 NOVEMBER      HR     MIN   - SEC TIME-START  .47520000 06  JULIAN DATE 1610.5000
LAT(DEG) -.21787319 02  LONG(DEG) .26191423 03   V.APO(FPS) .32703930 02  V.PERI(FPS) .39529493 03
ALT(NM)    .26207253 09  APO(NM)     .33101109 09  PERI(NM)    .27382377 08  PERIOD(MIN) .10028419 10
X  .18506044 01  Y -.23808051 01 Z  -.11972525 01   XD   .22322388-06   YD  -.13538713-06 ZD -.50954167-07
R  .32444388 01  A -.52142008 02 D  -.21654995 02    V   .26599794-06 BETA   .22653311 02 AZ  .65404737 02
A  .22184560 01  E  .84717749 00 I   .34993761 02 NODE  -.91480867 01     W  -.19197000 03  M  .14294682 01
R  .61447704-03  V  .21980007-03 G   .63989581-01    S  -.89988884 02  SVE   .17594603 02  F  .16215047 03
ELK  .12620530 03 MLK  .14940170 03 SLK  .14353546 03  RM  .90293654 05 RS  .75870108 05          ELLIPSE
ETA -.46617337-01 ZTA -.16340472 00 RHO  .75027830 05  XP  .12366037 05          VEHICLE IS NOT ECLIPSED
XMV  .76906281 05 YMV -.41404747 05 ZMV -.22891373 05  XM -.33500614 05 YM -.14436705 05  ZM -.51900181 04
XSV  .60073511 05 YSV -.40979379 05 ZSV -.21636478 05  XS -.16667843 05 YS -.14862072 05  ZS -.64449128 04

16 NOVEMBER      HR     MIN   - SEC TIME-START  .48960000 06  JULIAN DATE 1620.5000
LAT(DEG) -.21108823 02  LONG(DEG) .25373521 03   V.APO(FPS) .32613607 02  V.PERI(FPS) .39632420 03
ALT(NM)    .27895250 09  APO(NM)     .33120123 09  PERI(NM)    .27251463 08  PERIOD(MIN) .10030905 10
X  .20525379 01  Y -.24868246 01 Z  -.12364564 01   XD   .24347142-06   YD  -.10940814-06 ZD -.39529099-07
R  .34534089 01  A -.50464929 02 D  -.20979837 02    V   .26983518-06 BETA   .28272068 02 AZ  .67557500 02
A  .22188226 01  E  .84793316 00 I   .35032060 02 NODE  -.91859238 01     W  -.19196577 03  M  .14794903 01
R  .65405470-03  V  .23501669-03 G   .57937332-01    S  -.89988104 02  SVE   .16632106 02  F  .16290889 03
ELK  .12790710 03 MLK  .15231850 03 SLK  .14426712 03  RM  .88998848 05 RS  .77168104 05          ELLIPSE
ETA -.41993784-01 ZTA -.30964253 00 RHO  .77033287 05  XP  .24660176 05          VEHICLE IS NOT ECLIPSED
XMV  .78136196 05 YMV -.37184509 05 ZMV -.20804855 05  XM -.29994208 05 YM -.21143614 05  ZM -.81960574 04
XSV  .61691358 05 YSV -.41063781 05 ZSV -.21514149 05  XS -.13549370 05 YS -.17264342 05  ZS -.74867642 04

26 NOVEMBER      HR     MIN   - SEC TIME-START  .50400000 06  JULIAN DATE 1630.5000
LAT(DEG) -.20382037 02  LONG(DEG) .24580840 03   V.APO(FPS) .32702673 02  V.PERI(FPS) .39491422 03
ALT(NM)    .29516346 09  APO(NM)     .33131950 09  PERI(NM)    .27433264 08  PERIOD(MIN) .10043503 10
X  .22699271 01  Y -.25689022 01 Z  -.12651465 01   XD   .25887749-06   YD  -.80100435-07 ZD -.26674487-07
R  .36540967 01  A -.48535620 02 D  -.20256706 02    V   .27229609-06 BETA   .33766463 02 AZ  .68646982 02
A  .22206800 01  E  .84704686 00 I   .34985107 02 NODE  -.91411128 01     W  -.19192913 03  M  .15306607 01
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R   .69206378-03  V   .24984194-03 G    .51912263-01    S  -.89987361 02  SVE    .15396867 02   F   .16354412 03
ELK  .12985162 03 MLK  .15478876 03 SLK  .14497569 03  RM   .86859795 05 RS   .78416450 05          ELLIPSE
ETA -.37951564-01 ZTA -.45218335 00 RHO  .76930365 05  XP   .37420743 05             VEHICLE IS NOT ECLIPSED
XMV  .78027454 05 YMV -.33234660 05 ZMV -.18756274 05  XM  -.24786632 05 YM  -.27018582 05  ZM  -.10917559 05
XSV  .63260335 05 YSV -.41114607 05 ZSV -.21374257 05  XS  -.10019513 05 YS  -.19138635 05  ZS  -.82995762 04

 6 DECEMBER      HR     MIN  - SEC TIME-START  .51840000 06  JULIAN DATE 1640.5000
LAT(DEG) -.19608715 02  LONG(DEG) .23807651 03    V.APO(FPS) .32676754 02  V.PERI(FPS) .39571445 03
ALT(NM)    .31047608 09  APO(NM)    .33098297 09    PERI(NM)    .27328290 08  PERIOD(MIN) .10024968 10
X   .24983000 01  Y -.26245191 01 Z   -.12822419 01     XD    .26880574-06    YD   -.48305357-07 ZD -.12754192-07
R   .38436633 01  A -.46411403 02 D   -.19487360 02      V    .27340922-06 BETA    .39173604 02 AZ   .69147758 02
A   .22179472 01  E   .84744432 00 I    .35008655 02 NODE  -.91627438 01      W   -.19198186 03  M   .15860445 01
R   .72796653-03  V   .26406851-03 G    .45988947-01     S  -.89986660 02  SVE    .13941113 02   F   .16430214 03
ELK  .13198949 03 MLK  .15670134 03 SLK  .14566327 03  RM   .84039050 05 RS   .79612201 05          ELLIPSE
ETA -.34401553-01 ZTA -.59194502 00 RHO  .74598769 05  XP   .50273230 05             VEHICLE IS NOT ECLIPSED
XMV  .76715403 05 YMV -.29864675 05 ZMV -.16894083 05  XM  -.18118127 05 YM  -.31693054 05  ZM  -.13180721 05
XSV  .64778153 05 YSV -.41130851 05 ZSV -.21216659 05  XS  -.61808769 04 YS  -.20426878 05  ZS  -.88581448 04

16 DECEMBER      HR     MIN  - SEC TIME-START  .53280000 06  JULIAN DATE 1650.5000
LAT(DEG) -.18791099 02  LONG(DEG) .23049133 03    V.APO(FPS) .32622630 02  V.PERI(FPS) .39605725 03
ALT(NM)    .32468381 09  APO(NM)    .33130885 09    PERI(NM)    .27286243 08  PERIOD(MIN) .10036882 10
X   .27327125 01  Y -.26519278 01 Z   -.12869956 01     XD    .27279989-06    YD   -.14964674-07 ZD  .18246384-08
R   .40195517 01  A -.44140466 02 D   -.18674044 02      V    .27321612-06 BETA    .44535390 02 AZ   .69295147 02
A   .22197040 01  E   .84779958 00 I    .35024640 02 NODE  -.91774235 01      W   -.19194566 03  M   .16343952 01
R   .76127872-03  V   .27750[illegible] [illegible]    .40211164-01     S  -.89986011 02  SVE    .12306799 02   F   .16494397 03
ELK  [illegible]27864 03 [illegible] [illegible]793618 03 SLK  .14632928 03  RM   .80762075 05 RS   .80759298 05          ELLIPSE
[illegible] [illegible] [illegible] -.72946311 00 RHO  .70021458 05  XP   .62802713 05             VEHICLE IS NOT ECLIPSED
XMV  .74427099 05 YMV -.27339424 05 ZMV -.15351739 05  XM  -.10331709 05 YM  -.34861171 05  ZM  -.14834563 05
XSV  .66245963 05 YSV -.41118109 05 ZSV -.21043713 05  XS  -.21505732 04 YS  -.21082486 05  ZS  -.91425891 04

26 DECEMBER      HR     MIN  - SEC TIME-START  .54720000 06  JULIAN DATE 1660.5000
LAT(DEG) -.17932249 02  LONG(DEG) .22301215 03    V.APO(FPS) .32720180 02  V.PERI(FPS) .39480974 03
ALT(NM)    .33760308 09  APO(NM)    .33120959 09    PERI(NM)    .27446107 08  PERIOD(MIN) .10039427 10
X   .29679153 01  Y -.26502264 01 Z   -.12790263 01     XD    .27061141-06    YD    .18907534-07 ZD  .16623218-07
R   .41794891 01  A -.41763543 02 D   -.17819813 02      V    .27177998-06 BETA    .49892091 02 AZ   .69221282 02
A   .22200792 01  E   .84693385 00 I    .34979550 02 NODE  -.91377817 01      W   -.19194297 03  M   .16878412 01
R   .79156991-03  V   .28995633-03 G    .34598116-01     S  -.89985427 02  SVE    .10535425 02   F   .16555784 03
ELK  .13668276 03 MLK  .15837738 03 SLK  .14697831 03  RM   .77313520 05 RS   .81859915 05          ELLIPSE
ETA -.28481936-01 ZTA -.86510876 00 RHO  .63265002 05  XP   .74586312 05             VEHICLE IS NOT ECLIPSED
XMV  .71461632 05 YMV -.25846406 05 ZMV -.14233027 05  XM  -.18495928 04 YM  -.36314285 05  ZM  -.15766354 05
XSV  .67668042 05 YSV -.41074757 05 ZSV -.20855363 05  XS   .19439971 04 YS  -.21085934 05  ZS  -.91440188 04
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5 JANUARY        HR      MIN   - SEC TIME-START   .56160000 06  JULIAN DATE 1670.5000
LAT(DEG) -.17036198 02   LONG(DEG) .21560420 03    V.APO(FPS) .32641048 02   V.PERI(FPS) .39616172 03
ALT(NM)     .34907411 09   APO(NM)     .33102701 09    PERI(NM)     .27271228 08   PERIOD(MIN) .10024422 10
X  .31985366 01  Y -.26194065 01 Z   -.12583391 01    XD    .26220756-06    YD    .52258003-07 ZD  .31185429-07
R  .43214979 01  A -.39315384 02 D   -.16928687 02     V    .26917695-06 BETA    .55279592 02 AZ  .69007029 02
A  .22178665 01  E   .84775729 00 I    .35025461 02 NODE   -.91767777 01     W  -.19198283 03   M   .17418628 01
R  .81846550-03  V   .30126509-03 G    .29158025-01     S  -.89984924 02  SVE    .86590849 01   F   .16626175 03
ELK  .13917003 03 MLK   .15792156 03 SLK   .14761042 03  RM   .74028446 05 RS   .82911347 05          ELLIPSE
ETA -.25990775-01 ZTA -.99942819 00 RHO   .54460952 05   XP   .85231480 05            VEHICLE IS NOT ECLIPSED
XMV  .68155496 05 YMV -.25492609 05 ZMV -.13607580 05   XM   .68657334 04 YM -.35945204 05   ZM -.15906587 05
XSV  .69040943 05 YSV -.41001667 05 ZSV -.20651948 05   XS   .59802861 04 YS -.20436146 05   ZS -.88622183 04

15 JANUARY       HR      MIN   - SEC TIME-START   .57600000 06  JULIAN DATE 1680.5000
LAT(DEG) -.16108010 02   LONG(DEG) .20823738 03    V.APO(FPS) .32652327 02   V.PERI(FPS) .39559570 03
ALT(NM)     .35896249 09   APO(NM)     .33134132 09    PERI(NM)     .27345634 08   PERIOD(MIN) .10040739 10
X  .34192719 01  Y -.25603720 01 Z   -.12253344 01    XD    .24777762-06    YD    .84050987-07 ZD  .45063110-07
R  .44439137 01  A -.36826095 02 D   -.16005711 02     V    .26549764-06 BETA    .60733258 02 AZ  .68705062 02
A  .22202726 01  E   .84750740 00 I    .35008228 02 NODE   -.91627599 01     W  -.19193340 03   M   .17898953 01
R  .84165032-03  V   .31127443-03 G    .23890795-01     S  -.89984517 02  SVE    .67068623 01   F   .16681631 03
ELK  [illegible] 03 MLK   .15652095 03 SLK   .14822588 03  RM   .71290755 05 RS   .83918777 05          ELLIPSE
ETA -.23745678-01 ZTA -.11326643 01 RHO   .43836600 05   XP   .94359667 05            VEHICLE IS NOT ECLIPSED
XMV  .64871066 05 YMV -.26299394 05 ZMV -.13507721 05   XM   .15327478 05 YM -.33753773 05   ZM -.15232327 05
XSV  .70368067 05 YSV -.40903365 05 ZSV -.20435535 05   XS   .98304775 04 YS -.19149801 05   ZS -.83045127 04

25 JANUARY       HR      MIN   - SEC TIME-START   .59040000 06  JULIAN DATE 1690.5000
LAT(DEG) -.15153686 02   LONG(DEG) .20088539 03    V.APO(FPS) .32720425 02   V.PERI(FPS) .39492656 03
ALT(NM)     .36715933 09   APO(NM)     .33111645 09    PERI(NM)     .27430476 08   PERIOD(MIN) .10034860 10
X  .36250763 01  Y -.24748973 01 Z   -.11807895 01    XD    .22772980-06    YD    .11330706-06 ZD  .57832038-07
R  .45453887 01  A -.34321975 02 D   -.15056857 02     V    .26085225-06 BETA    .66286926 02 AZ  .68351024 02
A  .22194059 01  E   .84697460 00 I    .34983130 02 NODE   -.91423085 01     W  -.19195921 03   M   .18451620 01
R  .86086907-03  V   .31985008-03 G    .18790944-01     S  -.89984216 02  SVE    .47092540 01   F   .16742810 03
ELK  .14428254 03 MLK   .15425549 03 SLK   .14882862 03  RM   .69482483 05 RS   .84881562 05          ELLIPSE
ETA -.21705678-01 ZTA -.12649961 01 RHO   .31697757 05   XP   .10164141 06            VEHICLE IS NOT ECLIPSED
XMV  .61961540 05 YMV -.28191364 05 ZMV -.13922286 05   XM   .23064117 05 YM -.29857006 05   ZM -.13772965 05
XSV  .71651109 05 YSV -.40776742 05 ZSV -.20205335 05   XS   .13374548 05 YS -.17271528 05   ZS -.74899167 04

4 FEBRUARY       HR      MIN   - SEC TIME-START   .60480000 06  JULIAN DATE 1700.5000
LAT(DEG) -.14180099 02   LONG(DEG) .19352484 03    V.APO(FPS) .32613279 02   V.PERI(FPS) .39644109 03
ALT(NM)     .37358252 09   APO(NM)     .33111459 09    PERI(NM)     .27236026 08   PERIOD(MIN) .10026620 10
X  .38113451 01  Y -.23655670 01 Z   -.11258322 01    XD    .20267002-06    YD    .13913513-06 ZD  .69106304-07
R  .46249061 01  A -.31826410 02 D   -.14088959 02     V    .25536132-06 BETA    .71971743 02 AZ  .67969196 02
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A  .22181907 01  E  .84797601 00 I   .35037089 02 NODE  -.91846285 01     W  -.19197215 03  M  .18969374 01
R  .87592919-03  V  .32687954-03 G   .13852014-01    S  -.89984034 02   SVE   .26910467 01  F  .16806431 03
ELK  .14685770 03 MLK  .15137740 03 SLK  .14941722 03  RM  .68922530 05 RS  .85798631 05          ELLIPSE
ETA -.19835339-01 ZTA -.13968313 01 RHO  .18397124 05  XP  .10681819 06          VEHICLE IS NOT ECLIPSED
XMV  .59742643 05 YMV -.31016383 05 ZMV -.14802563 05  XM  .29651924 05 YM -.24467661 05  ZM -.11603674 05
XSV  .72887056 05 YSV -.40624906 05 ZSV -.19962447 05  XS  .16507511 05 YS -.14859138 05  ZS -.64437900 04

14 FEBRUARY     HR    MIN  - SEC TIME-START  .61920000 06  JULIAN DATE 1710.5000
LAT(DEG) -.13194915 02  LONG(DEG) .18613447 03   V.APO(FPS) .32689403 02  V.PERI(FPS) .39511667 03
ALT(NM)   .37817695 09  APO(NM)    .33130743 09   PERI(NM)    .27407080 08  PERIOD(MIN) .10041896 10
X  .39740672 01  Y -.22356796 01 Z   -.10618996 01    XD   .17336682-06    YD   .16077702-06 ZD  .78557872-07
R  .46817843 01  A -.29360675 02 D   -.13109639 02     V   .24915185-06 BETA   .77820113 02 AZ  .67575879 02
A  .22204432 01  E  .84717654 00 I    .34989655 02 NODE  -.91485944 01     W  -.19193297 03  M  .19462241 01
R  .88670157-03  V  .33227456-03 G    .90640703-02     S  -.89983979 02   SVE   .70694335 00  F  .16857175 03
ELK  .1[illegible]941446 03 MLK  .1[illegible]416 03 SLK  .14999336 03  RM  .69799461 05 RS  .86675058 05          ELLIPSE
ETA -.18103628-01 ZTA -.15283210 01 RHO  .45566490 04  XP  .10969357 06          VEHICLE IS NOT ECLIPSED
XMV  .58482461 05 YMV -.34550015 05 ZMV -.16064342 05  XM  .34728729 05 YM -.17887538 05  ZM -.88423661 04
XSV  .74080706 05 YSV -.40450015 05 ZSV -.19708143 05  XS  .19130484 05 YS -.11987538 05  ZS -.51985649 04

24 FEBRUARY     HR    MIN  - SEC TIME-START  .63360000 06  JULIAN DATE 1720.5000
LAT(DEG) -.12206505 02  LONG(DEG) .17869446 03   V.APO(FPS) .32701684 02  V.PERI(FPS) .39525754 03
ALT(NM)   .38091511 09  APO(NM)    .33106449 09   PERI(NM)    .27387505 08  PERIOD(MIN) .10030875 10
X  .41099592 01  Y -.20891234 01 Z   -.99068428 00    XD   .14072508-06    YD   .17763379-06 ZD  .85927205-07
R  .47156819 01  A -.26944575 02 D   -.12127212 02     V   .24236501-06 BETA   .83864818 02 AZ  .67181378 02
A  .22188182 01  E  .84717383 00 I    .34995380 02 NODE  -.91526391 01     W  -.19197253 03  M  .20022278 01
R  .89312157-03  V  .33597368-03 G    .44172419-02     S  -.89984061 02   SVE   .13717359 01  F  .16918080 03
ELK  .15193047 03 MLK  .14550695 03 SLK  .15055953 03  RM  .72105505 05 RS  .87507982 05          ELLIPSE
ETA -.1[illegible] ZTA  .462[illegible]539 01 RHO  .94656495 04  XP  .11015455 06          VEHICLE IS NOT ECLIPSED
XMV  .58368693 05 YMV -.38507577 05 ZMV -.17591646 05  XM  .38029824 05 YM -.10492520 05  ZM -.56447156 04
XSV  .75230872 05 YSV -.40249126 05 ZSV -.19441469 05  XS  .21167645 05 YS -.87509707 04  ZS -.37948918 04

5 MARCH         HR    MIN  - SEC TIME-START  .64800000 06  JULIAN DATE 1730.5000
LAT(DEG) -.11223867 02  LONG(DEG) .17118587 03   V.APO(FPS) .32606571 02  V.PERI(FPS) .39642090 03
ALT(NM)   .38179704 09  APO(NM)    .33120347 09   PERI(NM)    .27239120 08  PERIOD(MIN) .10030480 10
X  .42165658 01  Y -.19302319 01 Z   -.91407135 00    XD   .10574625-06    YD   .18927479-06 ZD  .91028065-07
R  .47266001 01  A -.24597049 02 D   -.11150615 02     V   .23514533-06 BETA   .90137349 02 AZ  .66790694 02
A  .22187600 01  E  .84799775 00 I    .35036646 02 NODE  -.91825954 01     W  -.19195574 03  M  .20516196 01
R  .89518941-03  V  .33794430-03 G   -.95512891-04     S  -.89984288 02   SVE   .33109786 01  F  .16974289 03
ELK  .15438355 03 MLK  .14336307 03 SLK  .15111388 03  RM  .75654723 05 RS  .88298609 05          ELLIPSE
ETA -.14948504-01 ZTA  .44919987 01 RHO  .23784983 05  XP  .10816816 06          VEHICLE IS NOT ECLIPSED
XMV  .59500478 05 YMV -.4257[illegible]34 05 ZMV -.19249729 05  XM  .39398482 05 YM -.26965864 04  ZM -.21896870 04
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XSV  .76336341 05 YSV -.40026790 05 ZSV -.19164124 05  XS  .22562620 05 YS -.52465298 04  ZS -.22752915 04

15 MARCH         HR     MIN  - SEC TIME-START  .66240000 06  JULIAN DATE 1740.5000
LAT(DEG) -.10256603 02  LONG(DEG) .16359136 03   V.APO(FPS) .32718229 02  V.PERI(FPS) .39479826 03
ALT(NM)     .38085011 09  APO(NM)     .33123975 09    PERI(NM)     .27447769 08  PERIOD(MIN) .10040763 10
X  .42923179 01   Y -.17636321 01 Z   -.83407281 00    XD    .69475305-07    YD    .19545168-06 ZD  .93753247-07
R  .47148772 01   A -.22336831 02 D   -.10189381 02     V    .22763534-06 BETA   .96671634 02 AZ  .66403951 02
A  .22202761 01   E   .84693816 00 I    .34977426 02 NODE  -.91409562 01       W  -.19194214 03  M  .21032585 01
R  .89296917-03   V   .33818377-03 G   -.44806869-02      S  -.89984665 02  SVE    .51930508 01  F  .17024054 03
ELK  .15675121 03 MLK   .14208585 03 SLK   .15165924 03  RM   .80136375 05 RS  .89050693 05          ELLIPSE
ETA -.13477259-01 ZTA   .43600026 01 RHO   .37709355 05  XP   .10378200 06          VEHICLE IS NOT ECLIPSED
XMV   .61886055 05 YMV -.46427714 05 ZMV -.20890719 05   XM   .38789660 05 YM   .50619702 04  ZM  .13276580 04
XSV  .77401952 05 YSV -.39782483 05 ZSV -.18876387 05   XS   .23273763 05 YS -.15832607 04  ZS -.68667383 03

25 MARCH         HR     MIN  - SEC TIME-START  .67680000 06  JULIAN DATE 1750.5000
LAT(DEG) -.93149235 01  LONG(DEG) .15588902 03   V.APO(FPS) .32667360 02  V.PERI(FPS) .39574903 03
ALT(NM)     .37812814 09  APO(NM)     .33105869 09    PERI(NM)     .27324294 08  PERIOD(MIN) .10027978 10
X  [illegible] 01   Y -.15940856 01 Z   -.75275879 00    XD    .32969969-07    YD    .19609947-06 ZD  .94074636-07
R  .46811799 01   A -.20183063 02 D   -.92535446 01     V    .21998195-06 BETA   .10350244 03 AZ  .66016099 02
A  .22183911 01   E   .84749715 00 I    .35013374 02 NODE  -.91653908 01       W  -.19197902 03  M  .21587251 01
R  .88658711-03   V   .33671978-03 G   -.87393836-02      S  -.89985204 02  SVE    .69852079 01  F  .17083454 03
ELK  .15901015 03 MLK   .14171979 03 SLK   .15219633 03  RM   .85176770 05 RS  .89760351 05          ELLIPSE
ETA -.12047662-01 ZTA   .42272900 01 RHO   .50757962 05  XP   .97122028 05          VEHICLE IS NOT ECLIPSED
XMV   .65426561 05 YMV -.49741849 05 ZMV -.22365060 05   XM   .36286682 05 YM   .12352795 05  ZM  .47092080 04
XSV  .78424273 05 YSV -.39514844 05 ZSV -.18577707 05   XS   .23288970 05 YS   .21257900 04  ZS  .92185449 03

4 APRIL          HR     MIN  - SEC TIME-START  .69120000 06  JULIAN DATE 1760.5000
LAT(DEG) -.84096481 01  LONG(DEG) .14806013 03   V.APO(FPS) .32626440 02  V.PERI(FPS) .39607012 03
ALT(NM)     .37371218 09  APO(NM)     .33125728 09    PERI(NM)     .27284295 08  PERIOD(MIN) .10034635 10
X  .43495209 01   Y -.14263360 01 Z   -.67219157 00    XD   -.27318252-08    YD    .19132347-06 ZD  .92038398-07
R  .46265113 01   A -.18155841 02 D   -.83541444 01     V    .21232805-06 BETA   .11065317 03 AZ  .65615301 02
A  .22193727 01   E   .84778772 00 I    .35022789 02 NODE  -.91719074 01       W  -.19194151 03  M  .22065036 01
R  .87623321-03   V   .33361158-03 G   -.12867826-01      S  -.89985911 02  SVE    .86637790 01  F  .17132981 03
ELK  .16113604 03 MLK   .14219608 03 SLK   .15272379 03  RM   .90410495 05 RS  .90430919 05          ELLIPSE
ETA -.10638957-01 ZTA   .40933121 01 RHO   .62563714 05  XP   .88370518 05          VEHICLE IS NOT ECLIPSED
XMV   .69934245 05 YMV -.52242819 05 ZMV -.23536077 05   XM   .32083158 05 YM   .18788307 05  ZM  .77699182 04
XSV  .79404529 05 YSV -.39228561 05 ZSV -.18269971 05   XS   .22612874 05 YS   .57740498 04  ZS  .25038120 04

14 APRIL         HR     MIN  - SEC TIME-START  .70560000 06  JULIAN DATE 1770.5000
LAT(DEG) -.75522791 01  LONG(DEG) .14008300 03   V.APO(FPS) .32729584 02  V.PERI(FPS) .39472488 03
ALT(NM)     .36771029 09  APO(NM)     .33117287 09    PERI(NM)     .27456855 08  PERIOD(MIN) .10038337 10
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X  .43323436 01   Y -.12649670 01  Z  -.59436343 00    XD  -.36657608-07    YD   .18138536-06  ZD   .87758233-07
R  .45522093 01   A -.16276861 02  D  -.75022960 01    V    .20480707-06  BETA   .11818949 03  AZ   .65179907 02
A  .22199184 01   E  .84686283 00  I   .34975615 02  NODE  -.91412278 01     W  -.19195572 03   M   .22606457 01
R  .86216085-03   V  .32894978-03  G  -.16851777-01    S   -.89986800 02   SVE   .10199438 02   F   .17184006 03
ELK  .16310327 03  MLK  .14339455 03  SLK  .15324495 03  RM  .95501370 05  RS  .91063726 05          ELLIPSE
ETA -.92306322-02  ZTA  .39577323 01  RHO  .72783065 05  XP  .77780402 05          VEHICLE IS NOT ECLIPSED
XMV  .75142485 05  YMV -.53705764 05  ZMV -.24286000 05  XM  .26472027 05  YM  .24036140 05  ZM  .10345289 05
XSV  .80345978 05  YSV -.38920855 05  ZSV -.17952524 05  XS  .21268534 05  YS  .92512314 04  ZS  .40118125 04

24 APRIL        HR     MIN  - SEC TIME-START  .72000000 06  JULIAN DATE 1780.5000
LAT(DEG) -.67551111 01   LONG(DEG) .13193370 03   V.APO(FPS) .32629414 02   V.PERI(FPS) .39623871 03
ALT(NM)   .36025735 09   APO(NM)   .33109458 09   PERI(NM)   .27261773 08   PERIOD(MIN) .10026861 10
X  .42869461 01   Y -.11142728 01  Z  -.52114128 00    XD  -.67917441-07    YD   .16669001-06  ZD   .81409802-07
R  .44599438 01   A -.14570045 02  D  -.67103009 01    V    .19754973-06  BETA   .12611648 03  AZ   .64671558 02
A  .22182262 01   E  .84783474 00  I   .35031575 02  NODE  -.91763642 01     W  -.19197471 03   M   .23143563 01
R  .84468632-03   V  .32285567-03  G  -.20664054-01    S   -.89987883 02   SVE   .11565158 02   F   .17240184 03
ELK  .16488497 03  MLK  .14517251 03  SLK  .15375897 03  RM  .10015695 06  RS  .91655559 05          ELLIPSE
ETA -.78021188-02  ZTA  .38200771 01  RHO  .81134471 05  XP  .65651032 05          VEHICLE IS NOT ECLIPSED
XMV  .80716098 05  YMV -.53987483 05  ZMV -.24529143 05  XM  .19833623 05  YM  .27852369 05  ZM  .12305847 05
XSV  .81244570 05  YSV -.38592745 05  ZSV -.17625585 05  XS  .19305150 05  YS  .12457631 05  ZS  .54022891 04

 4 MAY          HR     MIN  - SEC TIME-START  .73440000 06  JULIAN DATE 1790.5000
LAT(DEG) -.60313131 01   LONG(DEG) .12358559 03   V.APO(FPS) .32663327 02   V.PERI(FPS) .39554160 03
ALT(NM)   .35151637 09   APO(NM)   .33126307 09   PERI(NM)   .27352128 08   PERIOD(MIN) .10037726 10
X  .42159805 01   Y -.97814590 00  Z  -.45421741 00    XD  -.95718435-07    YD   .14776162-06  ZD   .73220862-07
R  .43517324 01   A -.13062046 02  D  -.59912295 01    V    .19067461-06  BETA   .13447558 03  AZ   .64018664 02
A  .22198284 01   E  .84744067 00  I   .35002079 02  NODE  -.91585576 01     W  -.19193597 03   M   .23621074 01
R  .82419173-03   V  .31548151-03  G  -.24261176-01    S   -.89989174 02   SVE   .12730516 02   F   .17285515 03
ELK  .16645351 03  MLK  .14739103 03  SLK  .15426560 03  RM  .10414374 06  RS  .92211000 05          ELLIPSE
ETA -.63324186-02  ZTA  .36795955 01  RHO  .87406535 05  XP  .52301491 05          VEHICLE IS NOT ECLIPSED
XMV  .86291680 05  YMV -.53038266 05  ZMV -.24219988 05  XM  .12593555 05  YM  .30095990 05  ZM  .13566383 05
XSV  .82103700 05  YSV -.38247633 05  ZSV -.17290737 05  XS  .16781534 05  YS  .15305358 05  ZS  .66371312 04

14 MAY          HR     MIN  - SEC TIME-START  .74880000 06  JULIAN DATE 1800.5000
LAT(DEG) -.53950176 01   LONG(DEG) .11500885 03   V.APO(FPS) .32721426 02   V.PERI(FPS) .39489581 03
ALT(NM)   .34168021 09   APO(NM)   .33112936 09   PERI(NM)   .27434521 08   PERIOD(MIN) .10035572 10
X  .41227341 01   Y -.85998354 00  Z  -.39506924 00    XD  -.11939132-06    YD   .12521755-06  ZD   .63459161-07
R  .42299631 01   A -.11782681 02  D  -.53591102 01    V    .18428452-06  BETA   .14329715 03  AZ   .63072942 02
A  .22195108 01   E  .84695928 00  I   .34983833 02  NODE  -.91475110 01     W  -.19196826 03   M   .24179741 01
R  .80112936-03   V  .30701438-03  G  -.27574206-01    S   -.89990690 02   SVE   .13658648 02   F   .17338060 03
ELK  .16778138 03  MLK  .14992309 03  SLK  .15476780 03  RM  .10727398 06  RS  .92728634 05          ELLIPSE
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ETA -.47999143-02 ZTA  .35357400 01 RHO  .91427811 05   XP  .38099521 05          VEHICLE IS NOT ECLIPSED
XMV  .91496887 05 YMV -.50898309 05 ZMV -.23353580 05   XM  .52012656 04 YM  .30727515 05  ZM  .14087286 05
XSV  .82923908 05 YSV -.37881809 05 ZSV -.16946786 05   XS  .13774244 05 YS  .17711015 05  ZS  .76804927 04

24 MAY         HR     MIN  - SEC TIME-START  .76320000 06  JULIAN DATE 1810.5000
LAT(DEG) -.48613473 01  LONG(DEG) .10617169 03   V.APO(FPS) .32604992 02  V.PERI(FPS) .39651218 03
ALT(NM)   .33097340 09  APO(NM)   .33115026 09   PERI(NM)   .27227155 08  PERIOD(MIN) .10027745 10
X  .40110176 01  Y -.76261166 00 Z  -.34492632 00   XD  -.13839497-06   YD   .99756197-07 ZD  .52427711-07
R  .40974153 01  A -.10765113 02 D  -.48289561 01   V    .17847446-06 BETA   .15260313 03 AZ  .61467403 02
A  .22183566 01  E  .84803688 00 I   .35040899 02 NODE -.91805177 01     W  -.19196113 03  M  .24691479 01
R  .77602563-03  V  .29765556-03 G  -.30501036-01   S  -.89992448 02  SVE   .14314404 02  F  .17389642 03
ELK  .16884231 03 MLK  .15264814 03 SLK  .15526373 03  RM  .10941298 06 RS  .93207111 05        ELLIPSE
ETA -.31825350-02 ZTA  .33877870 01 RHO  .93096481 05  XP  .23421928 05          VEHICLE IS NOT ECLIPSED
XMV  .95980625 05 YMV -.47709314 05 ZMV -.21971390 05  XM -.19027686 04 YM  .29822364 05  ZM  .13881191 05
XSV  .83702109 05 YSV -.37498474 05 ZSV -.16594788 05  XS  .10375747 05 YS  .19611524 05  ZS  .85045896 04

 3 JUNE        HR     MIN  - SEC TIME-START  .77760000 06  JULIAN DATE 1820.5000
LAT(DEG) -.44462826 01  LONG(DEG) .97033741 02   V.APO(FPS) .32702598 02  V.PERI(FPS) .39502623 03
ALT(NM)   .31965470 09  APO(NM)   .33123356 09   PERI(NM)   .27418306 08  PERIOD(MIN) .10039266 10
X  .38850531 01  Y -.68822679 00 Z  -.30474510 00   XD  -.15231556-06   YD   .72134180-07 ZD  .40454950-07
R  .39572925 01  A -.10045579 02 D  -.44166338 01   V    .17332043-06 BETA   .16238703 03 AZ  .57967940 02
A  .22200554 01  E  .84708724 00 I   .34982221 02 NODE -.91477058 01     W  -.19194120 03  M  .25186292 01
R  .74948721-03  V  .28767284-03 G  -.32902420-01   S  -.89994458 02  SVE   .14656360 02  F  .17434048 03
ELK  .16961156 03 MLK  .15545717 03 SLK  .15575459 03  RM  .11048300 06 RS  .93650974 05        ELLIPSE
ETA -.14582317-02 ZTA  .32347611 01 RHO  .92373994 05  XP  .86351715 04          VEHICLE IS NOT ECLIPSED
XMV  .99453686 05 YMV -.43694422 05 ZMV -.20155757 05  XM -.83303086 04 YM  .27552159 05  ZM  .13008003 05
XSV  .84442893 05 YSV -.37098651 05 ZSV -.16235542 05  XS  .66804844 04 YS  .20956388 05  ZS  .90877883 04

13 JUNE        HR     MIN  - SEC TIME-START  .79200000 06  JULIAN DATE 1830.5000
LAT(DEG) -.41662734 01  LONG(DEG) .87562178 02   V.APO(FPS) .32694442 02  V.PERI(FPS) .39529415 03
ALT(NM)   .30802010 09  APO(NM)   .33111509 09   PERI(NM)   .27383088 08  PERIOD(MIN) .10032814 10
X  .37[illegible] 01  Y -.63835827 00 Z  -.27519253 00   XD  -.16087694-06   YD   .43139080-07 ZD  .27882300-07
R  .[illegible]8132589 01  A -.96624042 01 D  -.41384782 01   V    .16887804-06 BETA   .17245281 03 AZ  .44421682 02
A  .22191041 01  E  .84721816 00 I   .35000453 02 NODE -.91574624 01     W  -.19197575 03  M  .25749208 01
R  .72220811-03  V  .27732669-03 G  -.34587952-01   S  -.89996726 02  SVE   .14640607 02  F  .17487062 03
ELK  .17006435 03 MLK  .15824699 03 SLK  .15624218 03  RM  .11045005 06 RS  .94056742 05        ELLIPSE
ETA  .39379928-03 ZTA  .30759287 01 RHO  .89273013 05  XP -.58687233 04          VEHICLE IS NOT ECLIPSED
XMV  .10169894 06 YMV -.39137828 05 ZMV -.18021365 05  XM -.13758196 05 YM  .24165224 05  ZM  .11566762 05
XSV  .85144032 05 YSV -.36679344 05 ZSV -.15867901 05  XS  .27967148 04 YS  .21706740 05  ZS  .94132987 04

23 JUNE        HR     MIN  - SEC TIME-START  .80640000 06  JULIAN DATE 1840.5000
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LAT(DEG) -.40373840 01  LONG(DEG) .77713256 02   V.APO(FPS) .32606968 02  V.PERI(FPS) .39642739 03
ALT(NM)    .29640481 09   APO(NM)    .33119412 09    PERI(NM)     .27238237 08  PERIOD(MIN) .10030051 10
X  .36086425 01  Y -.61384479 00 Z  -.25663608 00   XD  -.16394040-06    YD   .13582522-07 ZD  .15061982-07
R  .36694643 01  A -.96538405 01 D  -.40104431 01    V   .16519020-06 BETA   .17494857 03 AZ -.75822376 02
A  .22186967 01  E  .84799834 00 I   .35034913 02 NODE  -.91758401 01    W  -.19194580 03   M  .26236373 01
R  .69497430-03  V  .26693989-03 G  -.35318408-01    S  -.89999234 02  SVE   .14227651 02   F  .17533795 03
ELK  .17017163 03 MLK  .16091390 03 SLK  .15672441 03  RM  .10933605 06 RS  .94425485 05         ELLIPSE
ETA  .23909001-02 ZTA  .29104272 01 RHO  .83868185 05  XP -.19718879 05          VEHICLE IS NOT ECLIPSED
XMV  .10259693 06 YMV -.34371963 05 ZMV -.15710187 05  XM -.17956722 05 YM  .19974319 05  ZM  .96908236 04
XSV  .85804558 05 YSV -.36245011 05 ZSV -.15493532 05  XS -.11643525 04 YS  .21847367 05  ZS  .94741683 04

 3 JULY        HR    MIN  - SEC TIME-START  .82080000 06  JULIAN DATE 1850.5000
LAT(DEG) -.40736562 01  LONG(DEG) .67458325 02   V.APO(FPS) .32729423 02  V.PERI(FPS) .39469703 03
ALT(NM)    .28518306 09   APO(NM)    .33119621 09    PERI(NM)     .27460592 08  PERIOD(MIN) .10039473 10
X  .34676592 01  Y -.61481450 00 Z  -.24913486 00   XD  -.16149841-06    YD  -.15716284-07 ZD  .23493942-08
R  .35305418 01  A -.10054036 02 D  -.40464749 01    V   .16227833-06 BETA   .16407565 03 AZ  .25875276 03
A  .22200860 01  E  .84685355 00 I   .34972118 02 NODE  -.91436039 01    W  -.19195262 03   M  .26757984 01
R  .66866321-03  V  .25685309-03 G  -.34810434-01    S   .26999806 03  SVE   .13378027 02   F  .17579766 03
ELK  .16989671 03 MLK  .16335823 03 SLK  .15720370 03  RM  .10721661 06 RS  .94760235 05         ELLIPSE
ETA  .45435401-02 ZTA  .27373115 01 RHO  .76283544 05  XP -.32572991 05          VEHICLE IS NOT ECLIPSED
XMV  .10213842 06 YMV -.29736449 05 ZMV -.13374940 05  XM -.20804957 05 YM  .15316060 05  ZM  .75315170 04
XSV  [illegible] YSV -.35794052 05 ZSV -.15112247 05  XS -.50951680 04 YS  .21373664 05  ZS  .92688235 04

13 JULY        HR    MIN  - SEC TIME-START  .83520000 06  JULIAN DATE 1860.5000
LAT(DEG) -.42846701 01  LONG(DEG) .56767754 02   V.APO(FPS) .32656958 02  V.PERI(FPS) .39580532 03
ALT(NM)    .27476431 09   APO(NM)    .33112789 09    PERI(NM)     .27317348 08  PERIOD(MIN) .10030592 10
X  .33311243 01  Y -.64069711 00 Z  -.25244509 00   XD  -.15367444-06    YD  -.43956546-07 ZD -.99083199-08
R  .34015600 01  A -.10887124 02 D  -.42560908 01    V   .16014427-06 BETA   .15205995 03 AZ  .25417313 03
A  .22187765 01  E  .84756239 00 I   .35020730 02 NODE  -.91676369 01    W  -.19197426 03   M  .27311188 01
R  .64423485-03  V  .24742969-03 G  -.32760311-01    S   .26999526 03  SVE   .12065700 02   F  .17631564 03
ELK  .16919869 03 MLK  .16547834 03 SLK  .15768036 03  RM  .10421212 06 RS  .95056817 05         ELLIPSE
ETA  .68503659-02 ZTA  .25561195 01 RHO  .66700168 05  XP -.44086617 05          VEHICLE IS NOT ECLIPSED
XMV  .10041062 06 YMV -.25556794 05 ZNV -.11167948 05  XM -.22279566 05 YM  .10529333 05  ZM  .52468838 04
XSV  .87012249 05 YSV -.35325440 05 ZSV -.14723465 05  XS -.88811934 04 YS  .20297979 05  ZS  .88024011 04

23 JULY        HR    MIN  - SEC TIME-START  .84960000 06  JULIAN DATE 1870.5000
LAT(DEG) -.46721013 01  LONG(DEG) .45641140 02   V.APO(FPS) .32635722 02  V.PERI(FPS) .39600226 03
ALT(NM)    .26558178 09   APO(NM)    .33120831 09    PERI(NM)     .27292700 08  PERIOD(MIN) .10032933 10
X  .32035867 01  Y -.69024080 00 Z  -.26602744 00   XD  -.14072420-06    YD  -.70360166-07 ZD -.21373441-07
R  .32878824 01  A -.12159001 02 D  -.46409596 01    V   .15877870-06 BETA   .13943314 03 AZ  .25239269 03
A  .22191216 01  E  .84772361 00 I   .35016195 02 NODE  -.91656809 01    W  -.19193650 03   M  .27785333 01
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R    .62270500-03  V   .23906853-03 G   -.28906844-01      S    .26999251 03  SVE   .10286570 02  F   .17674881 03
ELK  .16804707 03 MLK  .16717066 03 SLK  .15815289 03  RM   .10050240 06 RS   .95318447 05          ELLIPSE
ETA  .92924485-02 ZTA  .23665880 01 RHO  .55346039 05  XP  -.53957804 05              VEHICLE IS NOT ECLIPSED
XMV  .97601580 05 YMV -.22123283 05 ZMV -.92316611 04  XM  -.22461901 05 YM   .59337815 04  ZM   .29920247 04
XSV  .87556981 05 YSV -.34843398 05 ZSV -.14328961 05  XS  -.12417303 05 YS   .18653897 05  ZS   .80893244 04

 2 AUGUST        HR      MIN   - SEC TIME-START   .86400000 06   JULIAN DATE 1880.5000
LAT(DEG) -.52256993 01   LONG(DEG) .34094989 02    V.APO(FPS) .32735352 02   V.PERI(FPS) .39464517 03
ALT(NM)    .25807110 09   APO(NM)     .33117105 09    PERI(NM)      .27467020 08   PERIOD(MIN) .10038686 10
X   .30893216 01  Y -.76153622 00 Z   -.28905721 00     XD   -.12302655-06     YD   -.94184733-07 ZD -.31724059-07
R   .31949020 01  A -.13847672 02 D   -.51909061 01      V    .15815407-06 BETA    .12630520 03 AZ   .25153769 03
A   .22199700 01  E   .84680970 00 I    .34973964 02 NODE   -.91458421 01      W   -.19196517 03  M   .28331945 01
R   .60509508-03  V   .23213582-03 G   -.23111826-01      S    .26999003 03  SVE    .80626557 01  F   .17723257 03
ELK  .16644306 03 MLK  .16833576 03 SLK  .15862423 03  RM   .96319294 05 RS   .95545723 05          ELLIPSE
ETA  .11828158-01 ZTA  .21688588 01 RHO  .42485693 05  XP  -.61924863 05              VEHICLE IS NOT ECLIPSED
XMV  .93978707 05 YMV -.19656635 05 ZMV -.76828343 04  XM  -.21519102 05 YM   .17949094 04  ZM   .90303778 03
XSV  .88065063 05 YSV -.34344541 05 ZSV -.13927756 05  XS  -.15605458 05 YS   .16482815 05  ZS   .71479593 04

12 AUGUST        HR      MIN   - SEC TIME-START   .87840000 06   JULIAN DATE 1890.5000
LAT(DEG) -.59199009 01   LONG(DEG) .22190554 02    V.APO(FPS) .32621486 02   V.PERI(FPS) .39627482 03
ALT(NM)    .25263719 09   APO(NM)     .33115328 09    PERI(NM)      .27257497 08   PERIOD(MIN) .10029145 10
X   .29922234 01  Y -.85205381 00 Z   -.32044090 00     XD   -.10107768-06     YD   -.11474973-06 ZD -.40665116-07
R   .31276315 01  A -.15894625 02 D   -.58805471 01      V    .15823353-06 BETA    .11278283 03 AZ   .25112672 03
A   .22185631 01  E   .84788171 00 I    .35037000 02 NODE   -.91741998 01      W   -.19196352 03  M   .28864064 01
R   .59235444-03  V   .22700835-03 G   -.15465388-01      S    .26998809 03  SVE    .54604348 01  F   .17772317 03
FLK  .16443624 03 MLK  .16886914 03 SLK  .15909326 03  RM   .91942826 05 RS   .95735271 05          ELLIPSE
ETA  .14391333-01 ZTA  .19640641 01 RHO  .28442725 05  XP  -.67751105 05              VEHICLE IS NOT ECLIPSED
XMV  .89859666 05 YMV -.18304582 05 ZMV -.66080170 04  XM  -.19677485 05 YM  -.16802207 04  ZM  -.90787958 03
XSV  .88532258 05 YSV -.33830278 05 ZSV -.13520134 05  XS  -.18350077 05 YS   .13845475 05  ZS   .60042371 04

22 AUGUST        HR      MIN   - SEC TIME-START   .89280000 06   JULIAN DATE 1900.5000
LAT(DEG) -.67129788 01   LONG(DEG) .10029166 02    V.APO(FPS) .32678806 02   V.PERI(FPS) .39540788 03
ALT(NM)    .24961232 09   APO(NM)     .33119762 09    PERI(NM)      .27368938 08   PERIOD(MIN) .10035684 10
X   .29157075 01  Y -.95870782 00 Z   -.35834367 00     XD   -.75492558-07     YD   -.13144298-06 ZD -.47930872-07
R   .30901844 01  A -.18201276 02 D   -.66684429 01      V    .15897720-06 BETA    .99005634 02 AZ   .25098191 03
A   .22195274 01  E   .84732622 00 I    .34992816 02 NODE   -.91551545 01      W   -.19193767 03  M   .29343092 01
R   .58526218-03  V   .22395929-03 G   -.63662470-02      S    .26998690 03  SVE    .25918612 01  F   .17814821 03
ELK  .16212891 03 MLK  .16866486 03 SLK  .15955974 03  RM   .87709479 05 RS   .95891478 05          ELLIPSE
ETA  .16896214-01 ZTA  .17539241 01 RHO  .13584466 05  XP  -.71257726 05              VEHICLE IS NOT ECLIPSED
XMV  .85601411 05 YMV -.18128917 05 ZMV -.60575305 04  XM  -.17213900 05 YM  -.43574412 04  ZM  -.23590975 04
XSV  .88962160 05 YSV -.33303229 05 ZSV -.13107430 05  XS  -.20574649 05 YS   .10816871 05  ZS   .46908022 04
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1 SEPTEMBER    HR    MIN  - SEC TIME-START  .90720000 06  JULIAN DATE 1910.5000
LAT(DEG) -.75502124 01  LONG(DEG)-.22609292 01   V.APO(FPS) .32719676 02  V.PERI(FPS) .39487445 03
ALT(NM)    .24921191 09  APO(NM)     .33116496 09   PERI(NM)    .27437488 08  PERIOD(MIN) .10037191 10
X  .28626110 01  Y -.10779175 01 Z  -.40271595 00   XD  -.46992033-07   YD  -.14373426-06 ZD -.53291589-07
R  .30852274 01  A -.20633888 02 D  -.75002426 01    V   .16033647-06 BETA   .85143989 02 AZ  .25101841 03
A  .22197495 01  E  .84695919 00 I   .34985965 02 NODE  -.91520840 01    W  -.19197458 03  M  .29904696 01
R  .58432337-03   V  .22320456-03 G   .34839423-02   S   .26998666 03  SVE   .50416528 00  F  .17864912 03
ELK  .15966665 03 MLK  .16764613 03 SLK  .16002626 03  RM  .83984451 05 RS  .96012247 05         ELLIPSE
ETA  .19250347-01 ZTA  .15407180 01 RHO  .29190965 04  XP -.72317442 05         VEHICLE IS NOT ECLIPSED
XMV  .81561655 05 YMV -.19094966 05 ZMV -.60387658 04  XM -.14419514 05 YM -.61874390 04  ZM -.34068806 04
XSV  .89354192 05 YSV -.32759537 05 ZSV -.12688292 05  XS -.22212051 05 YS  .74771313 04  ZS  .32426457 04

11 SEPTEMBER   HR    MIN  - SEC TIME-START  .92160000 06  JULIAN DATE 1920.5000
LAT(DEG) -.83713536 01  LONG(DEG)-.14520388 02   V.APO(FPS) .32602242 02  V.PERI(FPS) .39652433 03
ALT(NM)    .25150173 09  APO(NM)     .33117094 09   PERI(NM)    .27225724 08  PERIOD(MIN) .10028553 10
X  .28351127 01  Y -.12056894 01 Z  -.45032931 00   XD  -.16385585-07   YD  -.15119942-06 ZD -.56563266-07
R  .31135747 01  A -.23038610 02 D  -.83160956 01    V   .16226262-06 BETA   .71379291 02 AZ  .25118554 03
A  .22184758 01  E  .84805302 00 I   .35041262 02 NODE  -.91745647 01    W  -.19194819 03  M  .30410429 01
R  .58969218-03   V  .22480209-03 G   .13204905-01   S   .26998735 03  SVE   .34059122 01  F  .17910571 03
ELK  .15721778 03 MLK  .16582322 03 SLK  .16049083 03  RM  .81135301 05 RS  .96096335 05         ELLIPSE
ETA  .21372689-01 ZTA  .13273732 01 RHO  .17995618 05  XP -.70859289 05         VEHICLE IS NOT ECLIPSED
XMV  .78074776 05 YMV -.21088843 05 ZMV -.65212825 04  XM -.11577603 05 YM -.71904336 04  ZM -.40411287 04
XSV  [illegible] 05 YSV -.32202705 05 ZSV -.12263881 05  XS -.23208395 05 YS  .39234287 04  ZS  .17014701 04

21 SEPTEMBER   HR    MIN  - SEC TIME-START  .93600000 06  JULIAN DATE 1930.5000
LAT(DEG) -.91201467 01  LONG(DEG) .33339741 03   V.APO(FPS) .32716789 02  V.PERI(FPS) .39489537 03
ALT(NM)    .25638576 09  APO(NM)     .33118022 09   PERI(NM)    .27434877 08  PERIOD(MIN) .10037722 10
X  .28346474 01  Y -.13377121 01 Z  -.49981735 00   XD   .15429717-07   YD  -.15353469-06 ZD -.57614020-07
R  .31740380 01  A -.25263318 02 D  -.90601053 01    V   .16471294-06 BETA   .57886855 02 AZ  .25145157 03
A  .22198279 01  E  .84697915 00 I   .34975689 02 NODE  -.91490105 01    W  -.19194812 03  M  .30910374 01
R  .60114355-03   V  .22869933-03 G   .21936317-01   S   .26998888 03  SVE   .61727936 01  F  .17954854 03
ELK  .15494715 03 MLK  .16336490 03 SLK  .16095466 03  RM  .79485943 05 RS  .96147838 05         ELLIPSE
ETA  .23210403-01 ZTA  .11165700 01 RHO  .33011880 05  XP -.66879767 05         VEHICLE IS NOT ECLIPSED
XMV  .75437050 05 YMV -.23915881 05 ZMV -.74362188 04  XM -.89507910 04 YM -.74599690 04  ZM -.42869273 04
XSV  .90020594 05 YSV -.31632391 05 ZSV -.11834682 05  XS -.23534335 05 YS  .25704102 03  ZS  .11153552 03

1 OCTOBER      HR    MIN  - SEC TIME-START  .95040000 06  JULIAN DATE 1940.5000
LAT(DEG) -.97523074 01  LONG(DEG) .32162693 03   V.APO(FPS) .32687586 02  V.PERI(FPS) .39531279 03
ALT(NM)    .26362118 09  APO(NM)     .33117542 09   PERI(NM)    .27381043 08  PERIOD(MIN) .10035261 10
X  .28618472 01  Y -.14694686 01 Z  -.54922455 00   XD   .47493569-07   YD  -.15056674-06 ZD -.56368932-07
R  .32636108 01  A -.27179073 02 D  -.96882594 01    V   .16764080-06 BETA   .44812585 02 AZ  .25181115 03
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A  .22194649 01  E  .84725440 00 I   .35004300 02 NODE  -.91596168 01     W  -.19197666 03  M  .31472361 01
R  .61810810-03  V  .23470865-03 G   .29032184-01     S  .26999099 03  SVE   .86139417 01  F  .18005033 03
ELK  .15299248 03 MLK  .16059732 03 SLK  .16141922 03  RM  .79236565 05 RS  .96162759 05        ELLIPSE
ETA  .24746912-01 ZTA  .91047611 00 RHO  .47256063 05  XP -.60438413 05          VEHICLE IS NOT ECLIPSED
XMV  .73871250 05 YMV -.27315242 05 ZMV -.86804023 04  XM -.67470234 04 YM -.71509392 04  ZM -.42015828 04
XSV  .90296106 05 YSV -.31047374 05 ZSV -.11399559 05  XS -.23171880 05 YS -.34188069 04  ZS -.14824258 04

11 OCTOBER        HR    MIN  - SEC TIME-START  .96480000 06  JULIAN DATE 1950.5000
LAT(DEG) -.10239257 02  LONG(DEG) .31025428 03   V.APO(FPS) .32610995 02  V.PERI(FPS) .39640309 03
ALT(NM)    .27285311 09  APO(NM)   .33116886 09   PERI(NM)    .27241193 08  PERIOD(MIN) .10029115 10
X  .29165002 01  Y -.15963559 01 Z  -.59655809 00    XD  .78813386-07   YD  -.14227198-06 ZD -.52817622-07
R  .33778998 01  A -.28694236 02 D  -.10172143 02     V  .17100458-06 BETA   .32257134 02 AZ  .25232292 03
A  .22185587 01  E  .84797238 00 I   .35030558 02 NODE  -.91692824 01     W  -.19193527 03  M  .31955731 01
R  .63975375-03  V  .24253947-03 G   .34162283-01     S  .26999345 03  SVE   .10631879 02  F  .18048010 03
ELK  .15145008 03 MLK  .15792268 03 SLK  .16188246 03  RM  .80424319 05 RS  .96142234 05        ELLIPSE
ETA  .25999322-01 ZTA  .71084858 00 RHO  .60294330 05  XP -.51677092 05          VEHICLE IS NOT ECLIPSED
XMV  .73520246 05 YMV -.30988198 05 ZMV -.10127994 05  XM -.51141416 04 YM -.64541074 04  ZM -.38641927 04
XSV  .90531600 05 YSV -.30450503 05 ZSV -.10960188 05  XS -.22125495 05 YS -.69918022 04  ZS -.30319988 04

21 OCTOBER        HR    MIN  - SEC TIME-START  .97920000 06  JULIAN DATE 1960.5000
LAT(DEG) -.10567446 02  LONG(DEG) .29933530 03   V.APO(FPS) .32735296 02  V.PERI(FPS) .39464300 03
ALT(NM)    .28365801 09  APO(NM)   .33117410 09   PERI(NM)    .27467447 08  PERIOD(MIN) .10038833 10
X  .29975312 01  Y -.17138186 01 Z  -.63984574 00    XD  .10837895-06   YD  -.12878876-06 ZD -.47020106-07
R  .35116619 01  A -.29758476 02 D  -.10498277 02     V  .17476680-06 BETA   .20280494 02 AZ  .25326526 03
[illegible] 01  E  .84680881 00 I   .34971218 02 NODE  -.91486272 01     W  -.19196234 03  M  .32483712 01
R  .66508749-03  V  .25185655-03 G   .37295058-01     S  .26999602 03  SVE   .12179057 02  F  .18095458 03
ELK  .15037198 03 MLK  .15571707 03 SLK  .16234678 03  RM  .82908659 05 RS  .96088863 05        ELLIPSE
ETA  .27008333-01 ZTA  .51849383 00 RHO  .71737352 05  XP -.40803210 05          VEHICLE IS NOT ECLIPSED
XMV  .74437241 05 YMV -.34606066 05 ZMV -.11634570 05  XM -.41305664 04 YM -.55913091 04  ZM -.33729225 04
XSV  .90730678 05 YSV -.29840004 05 ZSV -.10516087 05  XS -.20424003 05 YS -.10357371 05  ZS -.44914054 04

31 OCTOBER        HR    MIN  - SEC TIME-START  .99360000 06  JULIAN DATE 1970.5000
LAT(DEG) -.10735006 02  LONG(DEG) .28888328 03   V.APO(FPS) .32646615 02  V.PERI(FPS) .39587243 03
ALT(NM)    .29558317 09  APO(NM)   .33118969 09   PERI(NM)    .27309230 08  PERIOD(MIN) .10032845 10
X  .31029892 01  Y -.18174936 01 Z  -.67719881 00    XD  .13519752-06   YD  -.11041993-06 ZD -.39107923-07
R  .36592926 01  A -.30358506 02 D  -.10664791 02     V  .17888644-06 BETA   .89161903 01 AZ  .25640881 03
A  .22191087 01  E  .84763051 00 I   .35025542 02 NODE  -.91665503 01     W  -.19196899 03  M  .33032536 01
R  .69304784-03  V  .26227006-03 G   .38609175-01     S  .26999857 03  SVE   .13243579 02  F  .18144133 03
ELK  .14977169 03 MLK  .15423313 03 SLK  .16281221 03  RM  .86400598 05 RS  .95998142 05        ELLIPSE
ETA  .27826206-01 ZTA  .33354658 00 RHO  .81231457 05  XP -.28088946 05          VEHICLE IS NOT ECLIPSED
XMV  .76568409 05 YMV -.37842399 05 ZMV -.13049711 05  XM -.37882324 04 YM -.47866582 04  ZM -.28338926 04
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XSV  .90888729 05 YSV -.29215426 05 ZSV -.10066845 05  XS -.18108553 05 YS -.13413631 05  ZS -.58167585 04

10 NOVEMBER     HR     MIN  - SEC TIME-START  .10080000 07  JULIAN DATE 1980.5000
LAT(DEG) -.10747576 02  LONG(DEG) .27887260 03   V.APO(FPS) .32643043 02  V.PERI(FPS) .39597316 03
ALT(NM)    .30817858 09  APO(NM)    .33115086 09   PERI(NM)    .27296095 08  PERIOD(MIN) .10030664 10
X  .32300929 01  Y -.19033500 01 Z   -.70687274 00   XD    .15833873-06    YD   -.87632759-07 ZD -.29283571-07
R  .38152208 01  A -.30508952 02 D   -.10677283 02   V     .18332534-06 BETA    .21279480 01 AZ   .45852585 02
A  .22187871 01  E   .84768171 00 I    .35010059 02 NODE  -.91618613 01     W   -.19193120 03  M   .33506359 01
R  .72257970-03  V   .27339505-03 G    .38393830-01   S   -.89999005 02  SVE    .13840103 02  F   .18186486 03
ELK  .14963447 03 MLK  .15357729 03 SLK  .16327736 03  RM  .90541859 05 RS   .95873242 05          ELLIPSE
ETA  .28506939-01 ZTA  .15594733 00 RHO  .88464096 05  XP -.13892879 05           VEHICLE IS NOT ECLIPSED
XMV  .79769523 05 YMV -.40399910 05 ZMV -.14230210 05  XM -.40081465 04 YM -.42428979 04  ZM -.23493915 04
XSV  .91007701 05 YSV -.28580509 05 ZSV -.96141327 04  XS -.15246324 05 YS -.16062299 05  ZS -.69654686 04

20 NOVEMBER     HR     MIN  - SEC TIME-START  .10224000 07  JULIAN DATE 1990.5000
LAT(DEG) -.10614851 02  LONG(DEG) .26928693 03   V.APO(FPS) .32731030 02  V.PERI(FPS) .39468730 03
ALT(NM)    .32101760 09  APO(NM)    .33118624 09   PERI(NM)    .27461793 08  PERIOD(MIN) .10039105 10
X  .33752945 01  Y -.19678326 01 Z   -.72732919 00   XD    .17696061-06    YD   -.61059951-07 ZD -.17821678-07
R  .39741648 01  A -.30242639 02 D   -.10545386 02   V     .18804517-06 BETA    .12211883 02 AZ   .66145603 02
A  .22200317 01  E   .84684311 00 I    .34977867 02 NODE  -.91519513 01     W   -.19197469 03  M   .34058200 01
[illegible]  V   .28488140-03 G    .36965534-01   S   -.89996763 02  SVE    .14005308 02  F   .18236803 03
ELK  .14992757 03 MLK  .15374197 03 SLK  .16374517 03  RM  .94952925 05 RS   .95714165 05          ELLIPSE
ETA  .29100231-01 ZTA -.14880529-01 RHO  .93195713 05  XP  .13864274 04            VEHICLE IS NOT ECLIPSED
XMV  .83807978 05 YMV -.42022467 05 ZMV -.15046361 05  XM -.46409170 04 YM -.41327715 04  ZM -.20130433 04
XSV  .91088897 05 YSV -.27931495 05 ZSV -.91567384 04  XS -.11921836 05 YS -.18223744 05  ZS -.79026659 04

30 NOVEMBER     HR     MIN  - SEC TIME-START  .10368000 07  JULIAN DATE 2000.5000
LAT(DEG) -.10348243 02  LONG(DEG) .26006699 03   V.APO(FPS) .32612382 02  V.PERI(FPS) .39635500 03
ALT(NM)    .33370833 09  APO(NM)    .33119083 09   PERI(NM)    .27247466 08  PERIOD(MIN) .10030300 10
X  .35343707 01  Y -.20079939 01 Z   -.73729356 00   XD    .19034613-06    YD   -.31477199-07 ZD -.50587556-08
R  .41312731 01  A -.29602351 02 D   -.10280446 02   V     .19299755-06 BETA    .21918874 02 AZ   .67703414 02
A  .22187335 01  E   .84794936 00 I    .35039439 02 NODE  -.91696567 01     W   -.19195350 03  M   .34584208 01
R  .78243808-03  V   .29635870-03 G    .34615965-01   S   -.89994714 02  SVE    .13780797 02  F   .18283053 03
ELK  .15060871 03 MLK  .15464157 03 SLK  .16421435 03  RM  .99276500 05 RS   .95517553 05          ELLIPSE
ETA  .29648845-01 ZTA -.17965724 00 RHO  .95258679 05  XP  .17307397 05            VEHICLE IS NOT ECLIPSED
XMV  .88374327 05 YMV -.42529209 05 ZMV -.15397016 05  XM -.54761562 04 YM -.45680073 04  ZM -.18961014 04
XSV  .91128073 05 YSV -.27270335 05 ZSV -.86951720 04  XS -.82299023 04 YS -.19826882 05  ZS -.85979452 04

10 DECEMBER     HR     MIN  - SEC TIME-START  .10512000 07  JULIAN DATE 2010.5000
LAT(DEG) -.99595538 01  LONG(DEG) .25117978 03   V.APO(FPS) .32684540 02  V.PERI(FPS) .39540859 03
ALT(NM)    .34589918 09  APO(NM)    .33113453 09   PERI(NM)    .27368477 08  PERIOD(MIN) .10033016 10
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X   .37025458 01  Y -.20216132 01 Z   -.73580648 00   XD   .19794765-06   YD   .22168319-09 ZD  .86177301-08
R   .42821929 01  A -.28634817 02 D   -.98941988 01    V   .19813528-06 BETA   .31149866 02 AZ  .68041841 02
A   .22191340 01  E  .84730173 00 I    .34988127 02 NODE  -.91557993 01    W  -.19193892 03  M  .35066654 01
R   .81102139-03  V  .30752802-03 G    .31592784-01    S  -.89992858 02  SVE   .13212984 02  F  .18327509 03
ELK  .15163192 03 MLK  .15615852 03 SLK  .16468484 03  RM  .10320843 06 RS  .95287529 05          ELLIPSE
ETA  .30188280-01 ZTA -.33888855 00 RHO  .94574813 05  XP  .33374380 05         VEHICLE IS NOT ECLIPSED
XMV  .93118697 05 YMV -.41824930 05 ZMV -.15217224 05  XM -.62760039 04 YM -.55917261 04  ZM -.20410135 04
XSV  .91128852 05 YSV -.26598936 05 ZSV -.82305709 04  XS -.42861592 04 YS -.20817720 05  ZS -.90276671 04

20 DECEMBER      HR     MIN   - SEC TIME-START  .10656000 07  JULIAN DATE 2020.5000
LAT(DEG) -.94603047 01  LONG(DEG) .24257045 03   V.APO(FPS) .32707156 02  V.PERI(FPS) .39498969 03
ALT(NM)   .35728113 09  APO(NM)    .33121216 09   PERI(NM)    .27422894 08  PERIOD(MIN) .10038560 10
X   .38746540 01  Y -.20072859 01 Z   -.72226246 00   XD   .19940848-06   YD   .33045307-07 ZD  .22777532-07
R   .44230987 01  A -.27386664 02 D   -.93981036 01    V   .20340735-06 BETA   .39935263 02 AZ  .68005081 02
A   .22199514 01  E  .84705449 00 I    .34993320 02 NODE  -.91569585 01    W  -.19198055 03  M  .35630075 01
R   .83770809-03  V  .31808718-03 G    .28093446-01    S  -.89991190 02  SVE   .12350575 02  F  .18379200 03
ELK  .15295139 03 MLK  .15816723 03 SLK  .16515916 03  RM  .10649239 06 RS  .95021507 05          ELLIPSE
ETA  .30747557-01 ZTA -.49331027 00 RHO  .91156819 05  XP  .49103739 05         VEHICLE IS NOT ECLIPSED
XMV  .97665748 05 YMV -.39903995 05 ZMV -.14481095 05  XM -.67862812 04 YM -.71766143 04  ZM -.24594700 04
XSV  .91089700 05 YSV -.25913554 05 ZSV -.77615099 04  XS -.21023340 03 YS -.21167055 05  ZS -.91790550 04

30 DECEMBER      HR     MIN   - SEC TIME-START  .10800000 07  JULIAN DATE 2030.5000
LAT(DEG) -.88615481 01  LONG(DEG) .23420018 03   V.APO(FPS) .32599936 02  V.PERI(FPS) .39656197 03
ALT(NM)   .36758753 09  APO(NM)    .33116711 09   PERI(NM)    .27220899 08  PERIOD(MIN) .10028190 10
X   .40453101 01  Y -.19644890 01 Z   -.69643866 00   XD   .19457988-06   YD   .65950299-07 ZD  .36968201-07
R   .45506897 01  A -.25902199 02 D   -.88031542 01    V   .20875205-06 BETA   .48309281 02 AZ  .67795586 02
A   .22184222 01  E  .84807628 00 I    .35040242 02 NODE  -.91685011 01    W  -.19193597 03  M  .36130232 01
R   .86187304-03  V  .32778547-03 G    .24269235-01    S  -.89989701 02  SVE   .11235243 02  F  .18423297 03
ELK  [illegible]345 03 MLK  .16054051 03 SLK  .16563527 03  RM  .10893183 06 RS  .94718234 05          ELLIPSE
[illegible]  .31350472-01 ZTA -.64358425 00 RHO  .85107957 05  XP  .64017101 05         VEHICLE IS NOT ECLIPSED
XMV  .10164946 06 YMV -.36665082 05 ZMV -.13209785 05  XM -.67672754 04 YM -.92117314 04  ZM -.31250868 04
XSV  .91008035 05 YSV -.25217988 05 ZSV -.72893478 04  XS  .38741475 04 YS -.20858825 05  ZS -.90455237 04

 9 JANUARY       HR     MIN   - SEC TIME-START  .10944000 07  JULIAN DATE 2040.5000
LAT(DEG) -.81738284 01  LONG(DEG) .22602270 03   V.APO(FPS) .32717342 02  V.PERI(FPS) .39494141 03
ALT(NM)   .37659274 09  APO(NM)    .33113853 09   PERI(NM)    .27428690 08  PERIOD(MIN) .10035712 10
X   .42090958 01  Y -.18936033 01 Z   -.65850393 00   XD   .18353652-06   YD   .97888127-07 ZD  .50735005-07
R   .46621721 01  A -.24222199 02 D   -.81198385 01    V   .21410693-06 BETA   .56306573 02 AZ  .67491819 02
A   .22195315 01  E  .84699323 00 I    .34974384 02 NODE  -.91534482 01    W  -.19195469 03  M  .36635874 01
R   .88298713-03  V  .33639300-03 G    .20230436-01    S  -.89988383 02  SVE   .99091624 01  F  .18471870 03
ELK  .15630756 03 MLK  .16316088 03 SLK  .16611461 03  RM  .11039103 06 RS  .94381408 05          ELLIPSE
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ETA  .32017060-01 ZTA -.79006622 00 RHO  .76638558 05  XP  .77642835 05          VEHICLE IS NOT ECLIPSED
XMV  .10475117 06 YMV -.32892160 05 ZMV -.11466320 05  XM -.60274189 04 YM -.11522041 05  ZM -.39787976 04
XSV  .90887837 05 YSV -.24511567 05 ZSV -.68142873 04  XS  .78359180 04 YS -.19902633 05  ZS -.86308302 04

19 JANUARY      HR     MIN  - SEC TIME-START  .11088000 07  JULIAN DATE 2050.5000
LAT(DEG) -.74072896 01  LONG(DEG) .21800660 03   V.APO(FPS) .32671810 02  V.PERI(FPS) .39545441 03
ALT(NM)    .38411115 09  APO(NM)    .33123794 09   PERI(NM)    .27363189 08  PERIOD(MIN) .10037136 10
X  .43607551 01  Y -.17959108 01 Z  -.60901827 00   XD   .16657789-06   YD   .12783583-06 ZD  .63633933-07
R  .47552481 01  A -.22383569 02 D  -.73582447 01    V   .21940709-06 BETA   .63957139 02 AZ  .67133437 02
A  .22197414 01  E  .84737300 00 I   .35013306 02 NODE  -.91616281 01    W  -.19197716 03  M  .37196096 01
R  .90061516-03  V  .34371383-03 G   .16057170-01    S  -.89987230 02  SVE   .84110064 01  F  .18523190 03
ELK  .15826651 03 MLK  .16591586 03 SLK  .16659863 03  RM  .11078170 06 RS  .94006695 05         ELLIPSE
ETA  .32764669-01 ZTA -.93331966 00 RHO  .66028428 05  XP  .89580371 05          VEHICLE IS NOT ECLIPSED
XMV  .10671238 06 YMV -.28242235 05 ZMV -.93503977 04  XM -.44314736 04 YM -.13880603 05  ZM -.49340405 04
XSV  .90725198 05 YSV -.23792044 05 ZSV -.63352890 04  XS  .11555704 05 YS -.18330794 05  ZS -.79491492 04

[illegible] JANUARY      HR     MIN  - SEC TIME-START  .11232000 07  JULIAN DATE 2060.5000
LAT(DEG) -.65717650 01  LONG(DEG) .21011329 03   V.APO(FPS) .32615769 02  V.PERI(FPS) .39639460 03
ALT(NM)    .38999572 09  APO(NM)    .33112327 09   PERI(NM)    .27242015 08  PERIOD(MIN) .10027236 10
X  .44953816 01  Y -.16735494 01 Z  -.54891294 00   XD   .14420717-06   YD   .15484551-06 ZD  .75253983-07
R  .48280978 01  A -.20419390 02 D  -.65281495 01    V   .22457960-06 BETA   .71290038 02 AZ  .66743461 02
A  .22182815 01  E  .84794680 00 I   .35026017 02 NODE  -.91643634 01    W  -.19192505 03  M  .37676622 01
R  .91441245-03  V  .34958403-03 G   .11806757-01    S  -.89986234 02  SVE   .67729018 01  F  .18566871 03
ELK  .16036615 03 MLK  .16869203 03 SLK  .16708531 03  RM  .11007450 06 RS  .93595280 05         ELLIPSE
ETA  .33609041-01 ZTA -.10738107 01 RHO  .53630944 05  XP  .99486506 05          VEHICLE IS NOT ECLIPSED
XMV  .10736746 06 YMV -.23231630 05 ZMV -.69939244 04  XM -.19289170 04 YM -.16021238 05  ZM -.58807518 04
XSV  .90519998 05 YSV -.23063736 05 ZSV -.58541191 04  XS  .14918549 05 YS -.16189133 05  ZS -.70205571 04

 8 FEBRUARY      HR     MIN  - SEC TIME-START  .11376000 07  JULIAN DATE 2070.5000
LAT(DEG) -.56768282 01  LONG(DEG) .20231877 03   V.APO(FPS) .32730117 02  V.PERI(FPS) .39472158 03
ALT(NM)    .39413572 09  APO(NM)    .33116963 09   PERI(NM)    .27457263 08  PERIOD(MIN) .10038218 10
X  .46085834 01  Y -.15294250 01 Z  -.47945228 00   XD   .11711012-06   YD   .17808778-06 ZD  .85235253-07
R  .48793499 01  A -.18359170 02 D  -.56390689 01    V   .22955410-06 BETA   .78334647 02 AZ  .66336254 02
A  .22199009 01  E  .84685934 00 I   .34973164 02 NODE  -.91545238 01    W  -.19197170 03  M  .38209901 01
R  .92411931-03  V  .35387163-03 G   .75144253-02    S  -.89985390 02  SVE   .50297948 01  F  .18619925 03
ELK  .16257501 03 MLK  .17137472 03 SLK  .16757726 03  RM  .10829223 06 RS  .93149113 05         ELLIPSE
ETA  .34565282-01 ZTA -.12117348 01 RHO  .39886020 05  XP  .10708200 06          VEHICLE IS NOT ECLIPSED
XMV  .10665580 06 YMV -.18195954 05 ZMV -.45447197 04  XM  .14378770 04 YM -.17676495 05  ZM -.67007664 04
XSV  .90274951 05 YSV -.22323812 05 ZSV -.53700921 04  XS  .17818728 05 YS -.13548637 05  ZS -.58753940 04

18 FEBRUARY      HR     MIN  - SEC TIME-START  .11520000 07  JULIAN DATE 2080.5000
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LAT(DEG) -.47318503 01  LONG(DEG) .19459118 03   V.APO(FPS) .32634586 02  V.PERI(FPS) .39597162 03
ALT(NM)    .39645477 09  APO(NM)    .33124439 09   PERI(NM)    .27296836 08  PERIOD(MIN) .10034621 10
X  .46966296 01  Y -.13671003 01 Z   -.40218587 00   XD   .86130507-07   YD   .19687122-06 ZD  .93277546-07
R  .49080593 01  A -.16229281 02 D   -.47003139 01    V   .23425935-06 BETA   .85117173 02 AZ  .65920522 02
A  .22193706 01  E   .84771762 00 I   .35030777 02 NODE  -.91641768 01     W  -.19196409 03  M  .38754369 01
R  .92955669-03  V   .35647707-03 G   .32048279-02    S  -.89984693 02  SVE   .32153132 01  F  .18669683 03
ELK  .16486354 03 MLK  .17383032 03 SLK  .16807454 03 RM  .10550095 06 RS  .92663509 05          ELLIPSE
ETA  .35648543-01 ZTA -.13475391 01 RHO  .25276891 05 XP  .11218946 06         VEHICLE IS NOT ECLIPSED
XMV  .10461501 06 YMV -.13472103 05 ZMV -.21569985 04  XM  .55437832 04 YM -.18593042 05  ZM -.72762149 04
XSV  .89985085 05 YSV -.21572367 05 ZSV -.48829695 04  XS  .20173706 05 YS -.10492778 05  ZS -.45502438 04

28 FEBRUARY     HR    MIN  - SEC TIME-START  .11664000 07  JULIAN DATE 2090.5000
LAT(DEG) -.37460607 01  LONG(DEG) .18691219 03   V.APO(FPS) .32653303 02  V.PERI(FPS) .39591554 03
ALT(NM)    .39690970 09  APO(NM)    .33108339 09   PERI(NM)    .27303084 08  PERIOD(MIN) .10028125 10
X  .47565718 01  Y -.11906688 01 Z   -.31889351 00   XD   .52222747-07   YD   .21066886-06 ZD  .99152359-07
R  .49136912 01  A -.14053540 02 D   -.37210524 01    V   .23862056-06 BETA   .91664347 02 AZ  .65500394 02
A  .22184126 01  E   .84761700 00 I   .35004180 02 NODE  -.91603202 01     W  -.19192720 03  M  .39229858 01
R  .93062333-03  V   .35733387-03 G  -.11113858-02    S  -.89984139 02  SVE   .13929061 01  F  .18715817 03
ELK  .16720290 03 MLK  .17588191 03 SLK  .16857593 03 RM  .10182269 06 RS  .92141556 05          ELLIPSE
ETA  .36874670-01 ZTA -.14815910 01 RHO  .10570338 05 XP  .11471365 06         VEHICLE IS NOT ECLIPSED
XMV  .10139050 06 YMV -.93715129 04 ZMV  .19733643 02  XM  .10174222 05 YM -.18555457 05  ZM -.74993362 04
XSV  .89652579 05 YSV -.20812754 05 ZSV -.43943833 04  XS  .21912147 05 YS -.71142161 04  ZS -.30852193 04

9 MARCH         HR    MIN  - SEC TIME-START  .11808000 07  JULIAN DATE 2100.5000
LAT(DEG) -.27285612 01  LONG(DEG) .17925450 03   V.APO(FPS) .32721345 02  V.PERI(FPS) .39477884 03
ALT(NM)    .39548782 09  APO(NM)    .33122083 09   PERI(NM)    .27450166 08  PERIOD(MIN) .10040069 10
X  .47863203 01  Y -.10046005 01 Z   -.23151839 00   XD   .16409897-07   YD   .21913768-06 ZD  .10271050-06
R  .48960887 01  A -.11853739 02 D   -.27103215 01    V   .24256969-06 BETA   .98004590 02 AZ  .65076062 02
A  .22201739 01  E   .84691775 00 I   .34982892 02 NODE  -.91571892 01     W  -.19198391 03  M  .39784060 01
R  .92728952-03  V   .35640798-03 G  -.54301241-02    S  -.89983726 02  SVE   .84128891 00  F  .18772101 03
ELK  .16956291 03 MLK  .17727508 03 SLK  .16908462 03 RM  .97424862 05 RS  .91582631 05          ELLIPSE
ETA  .38260865-01 ZTA  .46691459 01 RHO  .60914651 04 XP  .11464575 06         VEHICLE IS NOT ECLIPSED
XMV  .97213084 05 YMV -.61458623 04 ZMV  .18570363 04  XM  .15049389 05 YM -.17416902 05  ZM -.72872677 04
XSV  .89277669 05 YSV -.20041022 05 ZSV -.39030244 04  XS  .22984804 05 YS -.35217419 04  ZS -.15272070 04

19 MARCH        HR    MIN  - SEC TIME-START  .11952000 07  JULIAN DATE 2110.5000
LAT(DEG) -.16883395 01  LONG(DEG) .17160330 03   V.APO(FPS) .32608049 02  V.PERI(FPS) .39638512 03
ALT(NM)    .39220463 09  APO(NM)    .33121493 09   PERI(NM)    .27243757 08  PERIOD(MIN) .10031156 10
X  .47846864 01  Y -.81358224 00 Z   -.14209815 00   XD  -.20245989-07   YD   .22211455-06 ZD  .10388095-06
R  .48554435 01  A -.96502045 01 D   -.16770429 01    V   .24604070-06 BETA   .10416474 03 AZ  .64643636 02
A  .22188597 01  E   .84797870 00 I   .35040087 02 NODE  -.91642066 01     W  -.19194445 03  M  .40305342 01
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R  .91959158-03   V  .35369694-03 G   -.97533320-02    S  -.89983450 02  SVE    .26207769 01  F  .18820200 03
ELK  .17190735 03 MLK  .17781662 03 SLK  .16959932 03  RM  .92519569 05 RS  .90983274 05          ELLIPSE
ETA  .39826248-01 ZTA  .45378551 01 RHO  .19751125 05  XP  .11206465 06           VEHICLE IS NOT ECLIPSED
XMV  .92376600 05 YMV -.39822191 04 ZMV  .32521436 04  XM  .19847552 05 YM -.15100239 05  ZM -.65850360 04
XSV  .88856031 05 YSV -.19259705 05 ZSV -.34096647 04  XS  .23368120 05 YS  .17724683 03  ZS  .76772369 02

29 MARCH       HR    MIN  - SEC TIME-START  .12096000 07  JULIAN DATE 2120.5000
LAT(DEG) -.63432115 00  LONG(DEG) .16393356 03   V.APO(FPS) .32693939 02  V.PERI(FPS) .39535009 03
ALT(NM)   .38710201 09  APO(NM)   .33107730 09   PERI(NM)   .27375666 08  PERIOD(MIN) .10030916 10
X  .47513973 01  Y -.62236646 00 Z  -.52699007-01   XD  -.56692910-07   YD   .21961104-06 ZD  .10266860-06
R  .47922743 01  A -.74624588 01 D  -.63007485 00   V   .24896573-06 BETA   .11017340 03 AZ  .64194456 02
A  .22188243 01  E  .84724030 00 I   .34984426 02 NODE -.91584023 01    W  -.19194253 03  M  .40793155 01
R  .90762771-03  V  .34922913-03 G  -.14086434-01    S  -.89983309 02  SVE   .45070446 01  F  .18871629 03
ELK  .17417979 03 MLK  .17793839 03 SLK  .17012030 03  RM  .87375381 05 RS  .90347329 05          ELLIPSE
ETA  .41592488-01 ZTA  .44073440 01 RHO  .33551930 05  XP  .10712018 06           VEHICLE IS NOT ECLIPSED
XMV  .87226403 05 YMV -.29828450 04 ZMV  .41369707 04  XM  .24216956 05 YM -.11614673 05  ZM -.53730186 04
XSV  .88391163 05 YSV -.18470065 05 ZSV -.29152910 04  XS  .23052196 05 YS  .38725468 04  ZS  .16792432 04

 8 APRIL       HR    MIN  - SEC TIME-START  .12240000 07  JULIAN DATE 2130.5000
LAT(DEG)   .42456893 00  LONG(DEG) .15623140 03   V.APO(FPS) .32695595 02  V.PERI(FPS) .39507048 03
ALT(NM)    .38024595 09  APO(NM)   .33127566 09   PERI(NM)   .27412848 08  PERIOD(MIN) .10040804 10
X  .46870703 01  Y -.43562242 00 Z   .34648576-01   XD  -.91926402-07   YD   .21180797-06 ZD  .99151280-07
R  .47073979 01  A -.53098901 01 D   .42172663 00   V   .25128481-06 BETA   .11006200 03 AZ  .65714049 02
A  .22202822 01  E  .84713329 00 I   .34999822 02 NODE -.91596183 01    W  -.19198715 03  M  .41354629 01
R  .89155264-03  V  .34306214-03 G  -.18438265-01    S  -.89983303 02  SVE   .63688909 01  F  .18929196 03
ELK  .17624571 03 MLK  .17834779 03 SLK  .17065035 03  RM  .82302040 05 RS  .89671561 05          ELLIPSE
ETA  .43584416-01 ZTA  .42774020 01 RHO  .46264696 05  XP  .10003427 06           VEHICLE IS NOT ECLIPSED
XMV  .82119132 05 YMV -.31557369 04 ZMV  .44850218 04  XM  .27815447 05 YM -.70617260 04  ZM -.36723443 04
XSV  .87880375 05 YSV -.17668600 05 ZSV -.24185204 04  XS  .22054204 05 YS  .74511374 04  ZS  .32311978 04

18 APRIL       HR    MIN  - SEC TIME-START  .12384000 07  JULIAN DATE 2140.5000
LAT(DEG)   .14793533 01  LONG(DEG) .14847141 03   V.APO(FPS) .32604272 02  V.PERI(FPS) .39652678 03
ALT(NM)    .37172501 09  APO(NM)   .33114687 09   PERI(NM)   .27225272 08  PERIOD(MIN) .10027523 10
X  .45931686 01  Y -.25779434 00 Z   .11801137 00   XD  -.12500542-06   YD   .19903839-06 ZD  .93473201-07
R  .46019106 01  A -.32123897 01 D   .14694538 01   V   .25294243-06 BETA   .12186168 03 AZ  .63180000 02
A  .22183240 01  E  .84804515 00 I   .35035448 02 NODE -.91623979 01    W  -.19192568 03  M  .41852116 01
R  .87157398-03  V  .33528129-03 G  -.22817815-01    S  -.89983434 02  SVE   .81757483 01  F  .18976996 03
ELK  .17760289 03 MLK  .17923280 03 SLK  .17118754 03  RM  .77648846 05 RS  .88954695 05          ELLIPSE
ETA  .45830662-01 ZTA  .41474888 01 RHO  .57508057 05  XP  .91072546 05           VEHICLE IS NOT ECLIPSED
XMV  .77402755 05 YMV -.44274631 04 ZMV  .43074864 04  XM  .30329371 05 YM -.16190670 04  ZM -.15395462 04
XSV  .87321309 05 YSV -.16859332 05 ZSV -.19209283 04  XS  .20410817 05 YS  .10812801 05  ZS  .46888685 04
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28 APRIL        HR     MIN  - SEC TIME-START  .12528000 07  JULIAN DATE 2150.5000
LAT(DEG)  .25208724 01  LONG(DEG) .14063791 03   V.APO(FPS) .32720887 02  V.PERI(FPS) .39491921 03
ALT(NM)   .36164868 09  APO(NM)   .33111711 09   PERI(NM)   .27431429 08  PERIOD(MIN) .10034928 10
X  .44719266 01  Y -.92982790-01 Z   .19560495 00   XD  -.15508454-06   YD   .18176168-06 ZD  .85833188-07
R  .44771680 01  A -.11911542 01 D   .25040172 01    V   .25388158-06 BETA   .12760661 03 AZ  .62558125 02
A  .22194158 01  E  .84696998 00 I   .34974682 02 NODE  -.91588646 01    W  -.19196437 03  M  .42364154 01
R  .84794848-03  V  .32599765-03 G  -.27230031-01    S  -.89983707 02  SVE   .98992851 01  F  .19035201 03
ELK  .17716900 03 MLK  .17824352 03 SLK  .17173379 03  RM  .73786883 05 RS  .88199968 05       ELLIPSE
ETA  .48364394-01 ZTA  .40171252 01 RHO  .67006016 05  XP  .80542324 05         VEHICLE IS NOT ECLIPSED
XMV  .73396771 05 YMV -.66369235 04 ZMV  .36564148 04  XM  .31491641 05 YM  .44560251 04  ZM  .93147186 03
XSV  .86717331 05 YSV -.16041048 05 ZSV -.14225532 04  XS  .18171081 05 YS  .13860150 05  ZS  .60104399 04

8 MAY           HR     MIN  - SEC TIME-START  .12672000 07  JULIAN DATE 2160.5000
LAT(DEG)  .35396028 01  LONG(DEG) .13270201 03   V.APO(FPS) .32661621 02  V.PERI(FPS) .39550412 03
ALT(NM)   .35014612 09  APO(NM)   .33131070 09   PERI(NM)   .27357224 08  PERIOD(MIN) .10039940 10
X  .43262584 01  Y  .55155685-01 Z   .26583696 00   XD  -.18143510-06   YD   .16054557-06 ZD  .76477226-07
R  .43347691 01  A  .73042719 00 D   .35159656 01    V   .25405247-06 BETA   .13333475 03 AZ  .61795582 02
A  .22201548 01  E  .84743468 00 I   .35017969 02 NODE  -.91605163 01    W  -.19197954 03  M  .42919028 01
R  .82097900-03  V  .31534610-03 G  -.31678418-01    S  -.89984131 02  SVE   .11511222 02  F  .19092554 03
ELK  .17556469 03 MLK  .17563224 03 SLK  .17229080 03  RM  .71049513 05 RS  .87402520 05       ELLIPSE
ETA  .51224000-01 ZTA  .38859428 01 RHO  .74544143 05  XP  .68791415 05         VEHICLE IS NOT ECLIPSED
XMV  .70355719 05 YMV -.95520339 04 ZMV  .26200768 04  XM  .31116068 05 YM  .10845703 05  ZM  .36150918 04
XSV  .86063588 05 YSV -.15212111 05 ZSV -.92257776 03  XS  .15408199 05 YS  .16505780 05  ZS  .71577464 04

18 MAY          HR     MIN  - SEC TIME-START  .12816000 07  JULIAN DATE 2170.5000
LAT(DEG)  .45254529 01  LONG(DEG) .12464273 03   V.APO(FPS) .32626765 02  V.PERI(FPS) .39631470 03
ALT(NM)   .33736575 09  APO(NM)   .33106484 09   PERI(NM)   .27251884 08  PERIOD(MIN) .10025198 10
X  .41596578 01  Y  .18349680 00 Z   .32734546 00   XD  -.20344545-06   YD   .13605430-06 ZD  .65691797-07
R  .41765510 01  A  .25258760 01 D   .44952806 01    V   .25340922-06 BETA   .13908482 03 AZ  .60807681 02
A  .22179810 01  E  .84787311 00 I   .35019526 02 NODE  -.91607755 01    W  -.19191732 03  M  .43400671 01
R  .79101345-03  V  .30348375-03 G  -.36154190-01    S  -.89984715 02  SVE   .12984386 02  F  .19142952 03
ELK  .17374969 03 MLK  .17252740 03 SLK  .17285678 03  RM  .69679271 05 RS  .86563336 05       ELLIPSE
ETA  .54453711-01 ZTA  .37532109 01 RHO  .79998148 05  XP  .56164825 05         VEHICLE IS NOT ECLIPSED
XMV  .68463577 05 YMV -.12892445 05 ZMV  .13131528 04  XM  .29100614 05 YM  .17196337 05  ZM  .63646892 04
XSV  .85360079 05 YSV -.14376691 05 ZSV -.42291052 03  XS  .12204112 05 YS  .18680583 05  ZS  .81007526 04

28 MAY          HR     MIN  - SEC TIME-START  .12960000 07  JULIAN DATE 2180.5000
LAT(DEG)  .54674877 01  LONG(DEG) .11642403 03   V.APO(FPS) .32725035 02  V.PERI(FPS) .39475980 03
ALT(NM)   .32347591 09  APO(NM)   .33119538 09   PERI(NM)   .27452476 08  PERIOD(MIN) .10039098 10
X  .39760936 01  Y  .28952059 00 Z   .37903023 00   XD  -.22063524-06   YD   .10900900-06 ZD  .53790236-07
R  .40045981 01  A  .41646613 01 D   .54311036 01    V   .25190526-06 BETA   .14489855 03 AZ  .59449856 02
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A   .22200306 01  E   .84689499 00 I    .34977789 02 NODE  -.91603496 01     W   -.19198398 03  M   .43938262 01
R   .75844662-03  V   .29058916-03 G   -.40636058-01    S  -.89985481 02  SVE    .14282752 02  F   .19207417 03
ELK  .17199280 03 MLK  .16941451 03 SLK  .17343511 03  RM   .69756763 05 RS   .85683725 05          ELLIPSE
ETA  .58103906-01 ZTA  .36182476 01 RHO  .83293928 05  XP   .43022013 05          VEHICLE IS NOT ECLIPSED
XMV  .67816715 05 YMV -.16336564 05 ZMV -.12601831 03  XM   .25442006 05 YM   .23127229 05  ZM  .90161194 04
XSV  .84608459 05 YSV -.13531572 05 ZSV  .77309448 02  XS   .86502617 04 YS   .20322237 05  ZS  .88127916 04

 7 JUNE          HR     MIN  - SEC TIME-START  .13104000 07  JULIAN DATE 2190.5000
LAT(DEG)   .63534704 01  LONG(DEG) .10801558 03   V.APO(FPS) .32629352 02  V.PERI(FPS) .39597558 03
ALT(NM)    .30866519 09  APO(NM)   .33129852 09   PERI(NM)    .27296644 08  PERIOD(MIN) .10036886 10
X   .37798880 01  Y   .37135064 00 Z    .42006942 00   XD  -.23266312-06   YD    .80180087-07 ZD  .41105536-07
R   .38212450 01  A   .56109502 01 D    .63112797 01    V   .24950078-06 BETA   .15081865 03 AZ  .57451967 02
A   .22197045 01  E   .84774160 00 I    .35032256 02 NODE  -.91596938 01     W   -.19196095 03  M   .44475805 01
R   .72372063-03  V   .27686110-03 G   -.45080513-01    S  -.89986454 02  SVE    .15368736 02  F   .19264153 03
ELK  .17039265 03 MLK  .16675128 03 SLK  .17402605 03  RM   .71164263 05 RS   .84758653 05          ELLIPSE
ETA  .62230991-01 ZTA  .34804091 01 RHO  .84412287 05  XP   .29731681 05          VEHICLE IS NOT ECLIPSED
XMV  .68406991 05 YMV -.19555982 05 ZMV -.15490460 04  XM   .20249754 05 YM   .28265959 05  ZM  .11401716 05
XSV  .83803180 05 YSV -.12677641 05 ZSV  .57792297 03  XS   .48535654 04 YS   .21387619 05  ZS  .92747466 04

17 JUNE          HR     MIN  - SEC TIME-START  .13248000 07  JULIAN DATE 2200.5000
LAT(DEG)   .71693634 01  LONG(DEG) .99372438 02   V.APO(FPS) .32665071 02  V.PERI(FPS) .39584481 03
ALT(NM)    .29314426 09  APO(NM)   .33100966 09   PERI(NM)    .27311721 08  PERIOD(MIN) .10025393 10
X   .35755999 01  Y   .42779133 00 Z    .44993605 00   XD  -.23932045-06   YD    .50372423-07 ZD  .27986235-07
R   .36290994 01  A   .68225422 01 D    .71218606 01    V   .24616028-06 BETA   .15687708 03 AZ  .54242086 02
A   .22180097 01  E   .84754111 00 I    .34998147 02 NODE  -.91609077 01     W   -.19192465 03  M   .44956170 01
R   .68732943-03  V   .26251855-03 G   -.49409499-01    S  -.89987670 02  SVE    .16199554 02  F   .19320911 03
ELK  .16901392 03 MLK  .16487723 03 SLK  .17462892 03  RM   .73629730 05 RS   .83790821 05          ELLIPSE
ETA  .66896232-01 ZTA  .33386448 01 RHO  .83401815 05  XP   .16627474 05          VEHICLE IS NOT ECLIPSED
XMV  .70135087 05 YMV -.22237743 05 ZMV -.28088531 04  XM   .13730109 05 YM   .32271529 05  ZM  .13362040 05
XSV  .82946255 05 YSV -.11817786 05 ZSV  .10772838 04  XS   .91894141 03 YS   .21851571 05  ZS  .94759032 04

27 JUNE          HR     MIN  - SEC TIME-START  .13392000 07  JULIAN DATE 2210.5000
LAT(DEG)   .78986480 01  LONG(DEG) .90442305 02   V.APO(FPS) .32709126 02  V.PERI(FPS) .39486097 03
ALT(NM)    .27714895 09  APO(NM)   .33129039 09   PERI(NM)    .27439967 08  PERIOD(MIN) .10042562 10
X   .33679124 01  Y   .45834625 00 Z    .46840564 00   XD  -.24053121-06   YD    .20393838-07 ZD  .14783837-07
R   .34310814 01  A   .77498909 01 D    .78464289 01    V   .24184693-06 BETA   .16306509 03 AZ  .48361146 02
A   .22205413 01  E   .84699993 00 I    .34990068 02 NODE  -.91610877 01     W   -.19199554 03  M   .45511047 01
R   .64982601-03  V   .24780188-03 G   -.53493615-01    S  -.89989177 02  SVE    .16720642 02  F   .19389900 03
ELK  .16791612 03 MLK  .16396345 03 SLK  .17524776 03  RM   .76783011 05 RS   .82778837 05          ELLIPSE
ETA  .72162445-01 ZTA  .31919286 01 RHO  .80354334 05  XP   .40385615 04          VEHICLE IS NOT ECLIPSED
XMV  .72805467 05 YMV -.24099952 05 ZMV -.37665776 04  XM   .61884482 04 YM   .34850399 05  ZM  .14752966 05
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XSV  .82036500 05 YSV -.10948181 05 ZSV  .15766768 04  XS -.30425850 04 YS  .21698628 05  ZS  .94097120 04

 7 JULY         HR    MIN  - SEC TIME-START  .13536000 07  JULIAN DATE 2220.5000
LAT(DEG)  .85215282 01  LONG(DEG) .81173317 02   V.APO(FPS) .32612779 02  V.PERI(FPS) .39630691 03
ALT(NM)   .26094376 09  APO(NM)   .33122363 09   PERI(NM)   .27253802 08  PERIOD(MIN) .10031943 10
X  .31615141 01  Y  .46322361 00 Z   .47555849 00   XD  -.23635771-06   YD  -.89341089-08 ZD  .18473456-08
R  .32304649 01  A  .83356391 01 D   .84653077 01   V    .23653372-06 BETA   .16917157 03 AZ  .34901377 02
A  .22189757 01  E  .84793061 00 I   .35036370 02 NODE  -.91580579 01    W  -.19193709 03  M  .46026055 01
R  .61183047-03  V  .23297427-03 G  -.57134438-01   S   -.89991036 02  SVE   .16874891 02  F  .19447198 03
ELK  .16716174 03 MLK  .16402091 03 SLK  .17588167 03  RM  .80231787 05 RS  .81718854 05         ELLIPSE
ETA  .78087378-01 ZTA  .30391973 01 RHO  .75410588 05  XP -.77213572 04        VEHICLE IS NOT ECLIPSED
XMV  .76139223 05 YMV -.24927902 05 ZMV -.43079220 04  XM -.19863506 04 YM  .35792747 05  ZM  .15462080 05
XSV  .81069240 05 YSV -.10071953 05 ZSV  .20749213 04  XS -.69163682 04 YS  .20936798 05  ZS  .90792367 04

17 JULY         HR    MIN  - SEC TIME-START  .13680000 07  JULIAN DATE 2230.5000
LAT(DEG)  .90140495 01  LONG(DEG) .71495342 02   V.APO(FPS) .32699970 02  V.PERI(FPS) .39534081 03
ALT(NM)   .24482574 09  APO(NM)   .33101876 09   PERI(NM)   .27376518 08  PERIOD(MIN) .10028494 10
X  .29609825 01  Y  .44332206 00 Z   .47177369 00   XD  -.22699267-06   YD  -.36831272-07 ZD -.10479280-07
R  .30309276 01  A  .85151463 01 D   .89546835 01   V    .23019998-06 BETA   .17361625 03 AZ -.63126188 01
A  .22184672 01  E  .84721096 00 I   .34982826 02 NODE  -.91627933 01    W  -.19194522 03  M  .46520539 01
R  .57403931-03  V  .21832359-03 G  -.60036572-01   S   -.89993322 02  SVE   .16595581 02  F  .19513417 03
ELK  .16681836 03 MLK  .16496638 03 SLK  .17653185 03  RM  .83618917 05 RS  .80614107 05         ELLIPSE
ETA  .84711646-01 ZTA  .28789635 01 RHO  .68754707 05  XP -.18390230 05        VEHICLE IS NOT ECLIPSED
XMV  .79805156 05 YMV -.24583270 05 ZMV -.43500875 04  XM -.10355726 05 YM  .34981327 05  ZM  .15415473 05
XSV  .80047311 05 YSV -.91897701 04 ZSV  .25710868 04  XS -.10597881 05 YS  .19587827 05  ZS  .84942991 04

27 JULY         HR    MIN  - SEC TIME-START  .13824000 07  JULIAN DATE 2240.5000
LAT(DEG)  .93474690 01  LONG(DEG) .61344759 02   V.APO(FPS) .32681366 02  V.PERI(FPS) .39515387 03
ALT(NM)   .22912884 09  APO(NM)   .33136631 09   PERI(NM)   .27402631 08  PERIOD(MIN) .10044182 10
X  .27706753 01  Y  .40021320 00 Z   .45772118 00   XD  -.21275219-06   YD  -.62533981-07 ZD -.21868345-07
R  .28366037 01  A  .82193012 01 D   .92859832 01   V    .22282777-06 BETA   .17112340 03 AZ -.66267425 02
A  .22207801 01  E  .84722452 00 I   .35005942 02 NODE  -.91601205 01    W  -.19199492 03  M  .47078649 01
R  .53723555-03  V  .20416460-03 G  -.61782597-01   S   -.89996115 02  SVE   .15808660 02  F  .19585200 03
ELK  .16695712 03 MLK  .16667220 03 SLK  .17720214 03  RM  .86632988 05 RS  .79460569 05         ELLIPSE
ETA  .92037925-01 ZTA  .27098281 01 RHO  .60608596 05  XP -.27724132 05        VEHICLE IS NOT ECLIPSED
XMV  .83431087 05 YMV -.23015779 05 ZMV -.38473802 04  XM -.18445286 05 YM  .32402724 05  ZM  .14583167 05
XSV  .78966525 05 YSV -.82986608 04 ZSV  .30663057 04  XS -.13980724 05 YS  .17685605 05  ZS  .76694806 04

 6 AUGUST       HR    MIN  - SEC TIME-START  .13968000 07  JULIAN DATE 2250.5000
LAT(DEG)  .94883273 01  LONG(DEG) .50648803 02   V.APO(FPS) .32619310 02  V.PERI(FPS) .39637700 03
ALT(NM)   .21422615 09  APO(NM)   .33109816 09   PERI(NM)   .27244116 08  PERIOD(MIN) .10026270 10
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X   .25946252 01  Y   .33610001 00 Z    .43434368 00   XD  -.19407759-06   YD   -.85333814-07 ZD -.32013662-07
R   .26521119 01  A   .73808242 01 D    .94259486 01   V    .21441279-06 BETA   .16382760 03 AZ -.88335031 02
A   .22181391 01  E   .84792732 00 I    .35028240 02 NODE  -.91574739 01   W    -.19191681 03  M  .47573754 01
R   .50229392-03  V   .19083908-03 G   -.61824185-01   S   -.89999477 02  SVE   .14447019 02  F  .19646080 03
ELK  .16764668 03 MLK  .16899338 03 SLK  .17789122 03 RM  .89027960 05 RS  .78256495 05         ELLIPSE
ETA  .99999104-01 ZTA  .25304596 01 RHO  .51234479 05 XP -.35514602 05         VEHICLE IS NOT ECLIPSED
XMV  .86642185 05 YMV -.20279681 05 ZMV -.28007119 04 XM -.25785614 05 YM  .28162860 05  ZM  .12988182 05
XSV  .77824223 05 YSV -.74031041 04 ZSV  .35585838 04 XS -.16967651 05 YS  .15286283 05  ZS  .66288864 04

16 AUGUST        HR     MIN  - SEC TIME-START  .14112000 07  JULIAN DATE 2260.5000
LAT(DEG)  .94005872 01  LONG(DEG) .39359760 02  V.APO(FPS) .32718656 02  V.PERI(FPS) .39497139 03
ALT(NM)   .20052622 09  APO(NM)   .33110101 09  PERI(NM)   .27424600 08  PERIOD(MIN) .10033965 10
X   .24364260 01  Y   .25377957 00 Z    .40284054 00   XD  -.17153290-06   YD   -.10457898-06 ZD -.40633993-07
R   .24825100 01  A   .59465184 01 D    .93387647 01   V    .20496688-06 BETA   .15491421 03 AZ  .26295903 03
A   .22192739 01  E   .84699828 00 I    .34977986 02 NODE  -.91648889 01   W    -.19197183 03  M  .48091255 01
R   .47017235-03  V   .17871058-03 G   -.59513719-01   S    .26999658 03  SVE   .12453938 02  F  .19723317 03
ELK  .16893952 03 MLK  .17179011 03 SLK  .17860246 03 RM  .90621724 05 RS  .77004140 05         ELLIPSE
ETA  .10841583 00 ZTA  .23394493 01 RHO  .40922717 05 XP -.41610545 05         VEHICLE IS NOT ECLIPSED
XMV  .89094955 05 YMV -.16517129 05 ZMV -.12531165 04 XM -.31948924 05 YM  .22469493 05  ZM  .10701685 05
XSV  .76622348 05 YSV -.65013813 04 ZSV  .40479022 04 XS -.19476317 05 YS  .12453746 05  ZS  .54006664 04

26 AUGUST        HR     MIN  - SEC TIME-START  .14256000 07  JULIAN DATE 2270.5000
LAT(DEG)  .90510449 01  LONG(DEG) .27451719 02  V.APO(FPS) .32651376 02  V.PERI(FPS) .39553941 03
ALT(NM)   .18846017 09  APO(NM)   .33139527 09  PERI(NM)   .27353183 08  PERIOD(MIN) .10043322 10
X   .22991393 01  Y   .15657673 00 Z    .36463860 00   XD  -.14578692-06   YD   -.11969778-06 ZD -.47483122-07
R   .23331350 01  A   .38959601 01 D    .89914433 01   V    .19451486-06 BETA   .14488684 03 AZ  .25819116 03
A   .22206533 01  E   .84749146 00 I    .35020150 02 NODE  -.91575509 01   W    -.19198203 03  M  .48640079 01
R   .44188164-03  V   .16815086-03 G   -.54216322-01   S    .26999219 03  SVE   .98143201 01  F  .19797387 03
ELK  .17084658 03 MLK  .17490816 03 SLK  .17933868 03 RM  .91282365 05 RS  .75697789 05         ELLIPSE
ETA  .11695112 00 ZTA  .21361328 01 RHO  .30019625 05 XP -.45893208 05         VEHICLE IS NOT ECLIPSED
XMV  .90493466 05 YMV -.11953909 05 ZMV  .71194867 03 XM -.36567474 05 YM  .15626394 05  ZM  .78405987 04
XSV  .75354590 05 YSV -.55927289 04 ZSV  .45345901 04 XS -.21428598 05 YS  .92652142 04  ZS  .40179572 04

5 SEPTEMBER      HR     MIN  - SEC TIME-START  .14400000 07  JULIAN DATE 2280.5000
LAT(DEG)  .84195884 01  LONG(DEG) .14966413 02  V.APO(FPS) .32647898 02  V.PERI(FPS) .39614234 03
ALT(NM)   .17845196 09  APO(NM)   .33096723 09  PERI(NM)   .27273359 08  PERIOD(MIN) .10022003 10
X   .21852051 01  Y   .48268630-01 Z    .32135940 00   XD  -.11761187-06   YD   -.13021562-06 ZD -.52356822-07
R   .22092358 01  A   .12653912 01 D    .83640211 01   V    .18311170-06 BETA   .13382340 03 AZ  .25496185 03
A   .22175097 01  E   .84772089 00 I    .35011062 02 NODE  -.91595815 01   W    -.19191029 03  M  .49124262 01
R   .41841587-03  V   .15951242-03 G   -.45542683-01   S    .26998768 03  SVE   .66162044 01  F  .19866492 03
ELK  .17328517 03 MLK  .17795617 03 SLK  .17989816 03 RM  .90937415 05 RS  .74337709 05         ELLIPSE
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ETA   .12508677 00 ZTA   .19208666 01 RHO   .19004142 05  XP -.48294223 05
XMV   .90627636 05 YMV -.68845123 04 ZMV   .29746758 04                        VEHICLE IS NOT ECLIPSED
XSV   .74020372 05 YSV -.46813845 04 ZSV   .50164050 04  XM -.39373956 05 YM   .80166462 04  ZM   .45627639 04
                                                         XS -.22766692 05 YS   .58135185 04  ZS   .25210347 04
15 SEPTEMBER     HR     MIN   - SEC TIME-START  .14544000 07  JULIAN DATE 2290.5000
LAT(DEG)  .75134662 01  LONG(DEG) .20128909 01   V.APO(FPS) .32715069 02  V.PERI(FPS) .39485249 03
ALT(NM)   .17086809 09  APO(NM)   .33123217 09   PERI(NM)   .27440719 08  PERIOD(MIN) .10040149 10
X  .20963561 01  Y -.67003144-01 Z   .27478097 00  XD  -.87875663-07  YD  -.13576390-06 ZD -.55097457-07
R  .21153493 01  A -.18306484 01 D   .74637341 01  V    .17084993-06 BETA  .12176570 03 AZ  .25245657 03
A  .22201856 01  E  .84697123 00 I   .34983690 02 NODE -.91653389 01  W   -.19199386 03  M   .49663604 01
R  .40063434-03  V  .15308480-03 G  -.33663499-01  S    .26998361 03 SVE   .33401768 01  F   .19954448 03
ELK  .17590341 03 MLK  .17732485 03 SLK  .17910834 03  RM  .89562220 05 RS  .72924025 05        ELLIPSE
ETA  .13216154 00 ZTA  .16951873 01 RHO  .91694620 04  XP -.48802532 05          VEHICLE IS NOT ECLIPSED
XMV  .89384665 05 YMV -.16352140 04 ZMV  .53943473 04  XM -.40214926 05 YM  .63664581 02  ZM  .10506019 04
XSV  .72619286 05 YSV -.37641693 04 ZSV  .54939831 04  XS -.23449547 05 YS  .21926199 04  ZS  .95096612 03
25 SEPTEMBER     HR     MIN   - SEC TIME-START  .14688000 07  JULIAN DATE 2300.5000
LAT(DEG)  .63802032 01  LONG(DEG) .34879541 03   V.APO(FPS) .32629425 02  V.PERI(FPS) .39590784 03
ALT(NM)   .16595102 09  APO(NM)   .33135010 09   PERI(NM)   .27305628 08  PERIOD(MIN) .10039428 10
X  .20335384 01  Y -.18482975 00 Z   .22679516 00  XD  -.57514014-07  YD  -.13610172-06 ZD -.55602933-07
R  .20544771 01  A -.51933845 01 D   .63378378 01  V    .15787091-06 BETA  .10877899 03 AZ  .25033440 03
A  .22200793 01  E  .84771721 00 I   .35028151 02 NODE -.91545275 01  W   -.19195902 03  M   .50195448 01
R  .38910551-03  V  .14904072-03 G  -.19537499-01  S    .26998066 03 SVE   .32794607 01  F   .20032432 03
ELK  .17707380 03 MLK  .17389024 03 SLK  .17828484 03  RM  .87170240 05 RS  .71450630 05        ELLIPSE
ETA  .13750356 00 ZTA  .14625510 01 RHO  .85995533 04  XP -.47453274 05          VEHICLE IS NOT ECLIPSED
XMV  .86750436 05 YMV  .34509926 04 ZMV  .78168638 04  XM -.39054079 05 YM -.77861486 04  ZM -.24974150 04
XSV  .71144298 05 YSV -.28430270 04 ZSV  .59664556 04  XS -.23447940 05 YS -.14921290 04  ZS -.64700677 03
5 OCTOBER        HR     MIN   - SEC TIME-START  .14832000 07  JULIAN DATE 2310.5000
LAT(DEG)  .51095450 01  LONG(DEG) .33556892 03   V.APO(FPS) .32683687 02  V.PERI(FPS) .39572837 03
ALT(NM)   .16375769 09  APO(NM)   .33089664 09   PERI(NM)   .27325996 08  PERIOD(MIN) .10021250 10
X  .19968677 01  Y -.30065726 00 Z   .17935468 00  XD  -.27516712-07  YD  -.13113316-06 ZD -.53834256-07
R  .20273242 01  A -.85623910 01 D   .50755170 01  V    .14439945-06 BETA  .94933627 02 AZ  .24840721 03
A  .22173986 01  E  .84741939 00 I   .34994026 02 NODE -.91639316 01  W   -.19192180 03  M   .50681972 01
R  .38396291-03  V  .14739264-03 G  -.48278612-02  S    .26997942 03 SVE   .69559423 01  F   .20115206 03
ELK  .17499494 03 MLK  .17028235 03 SLK  .17742762 03  RM  .83821967 05 RS  .69919067 05        ELLIPSE
ETA  .14063178 00 ZTA  .12277956 01 RHO  .17385051 05  XP -.44338678 05          VEHICLE IS NOT ECLIPSED
XMV  .82822782 05 YMV  .80465341 04 ZMV  .10087730 05  XM -.35986529 05 YM -.15098408 05  ZM -.58809907 04
XSV  .69596110 05 YSV -.19207548 04 ZSV  .64318123 04  XS -.22759857 05 YS -.51311193 04  ZS -.22250734 04
15 OCTOBER       HR     MIN   - SEC TIME-START  .14976000 07  JULIAN DATE 2320.5000
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LAT(DEG)  .38185449 01  LONG(DEG) .32261200 03   V.APO(FPS) .32694239 02  V.PERI(FPS) .39497023 03
ALT(NM)   .16412806 09  APO(NM)   .33136811 09   PERI(NM)   .27426321 08  PERIOD(MIN) .10045252 10
X  .19855874 01  Y -.40991510 00 Z   .13441682 00   XD   .10904312-08   YD  -.12091625-06 ZD -.49820004-07
R  .20319093 01  A -.11664571 02 D   .37930554 01   V    .13078212-06 BETA   .80243130 02 AZ  .24649815 03
A  .22209379 01  E  .84710332 00 I   .34996059 02 NODE  -.91630646 01   W  -.19200412 03  M   .51233245 01
R  .38483130-03  V  .14796835-03 G   .85819758-02   S    .26998009 03  SVE   .10971090 02  F   .20213205 03
ELK  .17205672 03 MLK  .16675607 03 SLK  .17652926 03  RM  .79610029 05 RS  .68326371 05         ELLIPSE
ETA  .14142630 00 ZTA  .99599595 00 RHO  .26699828 05  XP -.39600167 05          VEHICLE IS NOT ECLIPSED
XMV  .77789332 05 YMV  .11871701 05 ZMV  .12068116 05  XM -.31217658 05 YM -.21486203 05  ZM -.89153878 04
XSV  .67970739 05 YSV -.99411914 03 ZSV  .68908218 04  XS -.21399065 05 YS -.86203823 04  ZS -.37380941 04

25 OCTOBER      HR     MIN  - SEC TIME-START  .15120000 07  JULIAN DATE 2330.5000
LAT(DEG)  .26249057 01  LONG(DEG) .31015276 03   V.APO(FPS) .32624847 02  V.PERI(FPS) .39615143 03
ALT(NM)   .16670394 09  APO(NM)   .33121185 09   PERI(NM)   .27273622 08  PERIOD(MIN) .10032280 10
X  .19980570 01  Y -.50815041 00 Z   .93884776-01   XD   .27287737-07   YD  -.10566989-06 ZD -.43658749-07
R  .20637982 01  A -.14269086 02 D   .26073568 01   V    .11754503-06 BETA   .64583075 02 AZ  .24432344 03
A  .22190255 01  E  .84782345 00 I   .35027240 02 NODE  -.91530398 01   W  -.19193086 03  M   .51746107 01
R  .39087086-03  V  .15043443-03 G   .19215040-01   S    .26998247 03  SVE   .14643958 02  F   .20299197 03
ELK  .16938254 03 MLK  .16344892 03 SLK  .17558791 03  RM  .74657058 05 RS  .66667382 05         ELLIPSE
ETA  .14015529 00 ZTA  .77187854 00 RHO  .35161669 05  XP -.33431349 05          VEHICLE IS NOT ECLIPSED
XMV  .71912963 05 YMV  .14702336 05 ZMV  .13639773 05  XM -.25048815 05 YM -.26620933 05  ZM -.11437719 05
XSV  .66261907 05 YSV -.67380737 02 ZSV  .73413233 04  XS -.19397759 05 YS -.11851216 05  ZS -.51392690 04

4 NOVEMBER      HR     MIN  - SEC TIME-START  .15264000 07  JULIAN DATE 2340.5000
LAT(DEG)  .16227044 01  LONG(DEG) .29834390 03   V.APO(FPS) .32709369 02  V.PERI(FPS) .39531815 03
ALT(NM)   .17099013 09  APO(NM)   .33093390 09   PERI(NM)   .27378936 08  PERIOD(MIN) .10025034 10
X  .20317638 01  Y -.59117459 00 Z   .59543713-01   XD   .50089980-07   YD  -.85785738-07 ZD -.35524760-07
R  .21168601 01  A -.16223210 02 D   .16118465 01   V    .10549980-06 BETA   .47676645 02 AZ  .24123356 03
A  .22179568 01  E  .84716231 00 I   .34983966 02 NODE  -.91685015 01   W  -.19194763 03  M   .52247447 01
R  .40092048-03  V  .15437859-03 G   .26365210-01   S    .26998606 03  SVE   .17734373 02  F   .20401088 03
ELK  .16730271 03 MLK  .16050076 03 SLK  .17459845 03  RM  .69123789 05 RS  .64943557 05         ELLIPSE
ETA  .13734738 00 ZTA  .55874634 00 RHO  .42374114 05  XP -.26073113 05          VEHICLE IS NOT ECLIPSED
XMV  .65518483 05 YMV  .16396236 05 ZMV  .14717001 05  XM -.17863748 05 YM -.30262153 05  ZM -.13320411 05
XSV  .64469926 05 YSV  .85866284 03 ZSV  .77818330 04  XS -.16815191 05 YS -.14724580 05  ZS -.63852435 04

14 NOVEMBER     HR     MIN  - SEC TIME-START  .15408000 07  JULIAN DATE 2350.5000
LAT(DEG)  .87139055 00  LONG(DEG) .28724870 03   V.APO(FPS) .32666580 02  V.PERI(FPS) .39522828 03
ALT(NM)   .17643124 09  APO(NM)   .33147011 09   PERI(NM)   .27393653 08  PERIOD(MIN) .10048164 10
X  .20833685 01  Y -.65521202 00 Z   .32995384-01   XD   .68574502-07   YD  -.61823982-07 ZD -.25666466-07
R  .21842197 01  A -.17458176 02 D   .86555766 00   V    .95830238-07 BETA   .29305411 02 AZ  .23495822 03
A  .22213671 01  E  .84731492 00 I   .35008571 02 NODE  -.91587387 01   W  -.19200085 03  M   .52798246 01
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R  .41367798-03  V  .15930322-03 G   .30057337-01    S   .26999031 03  SVE   .20144820 02  F  .20510277 03
ELK  .16594554 03 MLK  .15807417 03 SLK  .17355177 03  RM  .63195875 05 RS  .63148864 05        ELLIPSE
ETA  .13360399 00 ZTA  .35805242 00 RHO  .48122964 05  XP -.17793796 05          VEHICLE IS NOT ECLIPSED
XMV  .58952639 05 YMV  .16901052 05 ZMV  .15253179 05  XM -.10087520 05 YM -.32268958 05  ZM -.14479277 05
XSV  .62587117 05 YSV  .17855531 04 ZSV  .82124043 04  XS -.13721999 05 YS -.17153459 05  ZS -.74385021 04

24 NOVEMBER    HR    MIN  - SEC TIME-START  .15552000 07  JULIAN DATE 2360.5000
LAT(DEG)  .39828086 00  LONG(DEG) .27687975 03   V.APO(FPS) .32641070 02  V.PERI(FPS) .39618517 03
ALT(NM)   .18247677 09  APO(NM)   .33100866 09   PERI(NM)   .27268120 08  PERIOD(MIN) .10023522 10
X  .21487807 01  Y -.69703659 00 Z   .15598195-01   XD   .81928585-07   YD   -.34495424-07 ZD -.14398327-07
R  .22590621 01  A -.17972390 02 D   .39561454 00   V    .90052978-07 BETA   .10747767 02 AZ  .20664949 03
A  .22177337 01  E  .84776552 00 I   .35018276 02 NODE -.91549014 01    W   -.19190781 03  M   .53296157 01
R  .42785267-03  V  .16474306-03 G   .30771444-01   S    .26999477 03  SVE   .21858882 02  F   .20611401 03
ELK  .16533871 03 MLK  .15637765 03 SLK  .17244436 03  RM  .57092791 05 RS  .61279382 05        ELLIPSE
ETA  .12945572 00 ZTA  .17021121 00 RHO  .52273560 05  XP -.89002201 04          VEHICLE IS NOT ECLIPSED
XMV  .52567996 05 YMV  .16247288 05 ZMV  .15238712 05  XM -.21686455 04 YM -.32596184 05  ZM -.14872859 05
XSV  .60608234 05 YSV  .27077029 04 ZSV  .86297736 04  XS -.10208884 05 YS -.19056599 05  ZS -.82639200 04

 4 DECEMBER    HR    MIN  - SEC TIME-START  .15696000 07  JULIAN DATE 2370.5000
LAT(DEG)  .20780850 00  LONG(DEG) .26719082 03   V.APO(FPS) .32713173 02  V.PERI(FPS) .39508102 03
ALT(NM)   .18862292 09  APO(NM)   .33107588 09   PERI(NM)   .27410314 08  PERIOD(MIN) .10032311 10
X  .22232684 01  Y -.71409517 00 Z   .84127357-02   XD   .89482073-07   YD   -.46515355-08 ZD -.20974460-08
R  .23351499 01  A -.17806582 02 D   .20641728 00   V    .89627435-07 BETA   .14910194 02 AZ  .95997245 02
A  .22190300 01  E  .84706116 00 I   .34984046 02 NODE -.91704782 01    W   -.19197640 03  M   .53817269 01
R  .44226323-03  V  .17025780-03 G   .29146727-01   S    .26999918 03  SVE   .22919743 02  F   .20737418 03
ELK  .16545339 03 MLK  .15565953 03 SLK  .17126553 03  RM  .51077245 05 RS  .59334937 05        ELLIPSE
ETA  .12529901 00 ZTA -.52368964-02 RHO  .54767549 05  XP  .28457810 03          VEHICLE IS NOT ECLIPSED
XMV  .46697617 05 YMV  .14558106 05 ZMV  .14706432 05  XM  .54488320 04 YM -.31307109 05  ZM -.14509112 05
XSV  .58531146 05 YSV  .36259646 04 ZSV  .90328356 04  XS -.63846973 04 YS -.20374967 05  ZS -.88355160 04

14 DECEMBER    HR    MIN  - SEC TIME-START  .15840000 07  JULIAN DATE 2380.5000
LAT(DEG)  .29111798 00  LONG(DEG) .25812079 03   V.APO(FPS) .32641932 02  V.PERI(FPS) .39554143 03
ALT(NM)   .19443192 09  APO(NM)   .33149689 09   PERI(NM)   .27353517 08  PERIOD(MIN) .10047603 10
X  .23015886 01  Y -.70462723 00 Z   .12148285-01   XD   .90731290-07   YD    .26738223-07 ZD  .10806132-07
R  .24070640 01  A -.17021874 02 D   .28916905 00   V    .95204370-07 BETA   .33940873 02 AZ  .78708896 02
A  .22212844 01  E  .84753293 00 I   .35017570 02 NODE -.91536395 01    W   -.19198388 03  M   .54358095 01
R  .45588334-03  V  .17547153-03 G   .25789812-01   S   -.89996600 02  SVE   .23397171 02  F   .20862998 03
ELK  .16623324 03 MLK  .15619132 03 SLK  .17000342 03  RM  .45445765 05 RS  .57307001 05        ELLIPSE
ETA  .12139452 00 ZTA -.16938324 00 RHO  .55616347 05  XP  .94472263 04          VEHICLE IS NOT ECLIPSED
XMV  .41619271 05 YMV  .12030961 05 ZMV  .13726245 05  XM  .12364167 05 YM -.28557894 05  ZM -.13441309 05
XSV  .56344969 05 YSV  .45387241 04 ZSV  .94200266 04  XS -.23615298 04 YS -.21065657 05  ZS -.91350902 04
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24 DECEMBER      HR    MIN  - SEC TIME-START  .15984000 07  JULIAN DATE 2390.5000
LAT(DEG)  .63343304 00  LONG(DEG) .24959856 03   V.APO(FPS) .32671788 02  V.PERI(FPS) .39600569 03
ALT(NM)   .19953690 09  APO(NM)   .33081221 09   PERI(NM)   .27289949 08  PERIOD(MIN) .10016195 10
X  .23781459 01  Y -.66774467 00 Z  .27126603-01   XD  .85368123-07   YD  .58633094-07 ZD  .23849369-07
R  .24702625 01  A -.15683877 02 D  .62919269 00    V  .10627487-06 BETA  .51196486 02 AZ  .73790338 02
A  .22166528 01  E  .84756938 00 I  .35005579 02 NODE -.91604829 01   W -.19190031 03  M  .54850102 01
R  .46785274-03  V  .18004259-03 G  .21193560-01    S -.89992641 02  SVE  .23365572 02  F  .20990636 03
ELK  .16761359 03 MLK  .15619948 03 SLK  .16864908 03  RM  .40537028 05 RS  .55192457 05      ELLIPSE
ETA  .11789402 00 ZTA -.32312708 00 RHO  .54897681 05  XP  .18270067 05      VEHICLE IS NOT ECLIPSED
XMV  .37549399 05 YMV  .89212959 04 ZMV  .12397731 05  XM  .18229681 05 YM -.24583154 05  ZM -.11761480 05
XSV  .54044665 05 YSV  .54400159 04 ZSV  .97871194 04  XS  .17344145 04 YS -.21101874 05  ZS -.91508686 04

 3 JANUARY       HR    MIN  - SEC TIME-START  .16128000 07  JULIAN DATE 2400.5000
LAT(DEG)  .12186889 01  LONG(DEG) .24157485 03   V.APO(FPS) .32695866 02  V.PERI(FPS) .39505200 03
ALT(NM)   .20363891 09  APO(NM)   .33128703 09   PERI(NM)   .27415298 08  PERIOD(MIN) .10041384 10
X  .24471705 01  Y -.60347688 00 Z  .53260100-01   XD  .73295538-07   YD  .89949782-07 ZD  .36547386-07
R  .25210443 01  A -.13852853 02 D  .12105325 01    V  .12165077-06 BETA  .65530882 02 AZ  .71304899 02
A  .22203678 01  E  .84712552 00 I  .34991891 02 NODE -.91682234 01   W -.19199883 03  M  .55387229 01
R  .47747051-03  V  .18368726-03 G  .15716949-01    S -.89988928 02  SVE  .22906577 02  F  .21147747 03
ELK  .16953221 03 MLK  .16166323 03 SLK  .16718283 03  RM  .36698633 05 RS  .52987572 05      ELLIPSE
ETA  .11487228 00 ZTA -.46733580 00 RHO  .52754313 05  XP  .26463387 05      VEHICLE IS NOT ECLIPSED
XMV  .34618960 05 YMV  .55350703 04 ZMV  .10848056 05  XM  .22779082 05 YM -.19689536 05  ZM -.95988474 04
XSV  .51623146 05 YSV  .63306265 04 ZSV  .10132490 05  XS  .57748955 04 YS -.20485092 05  ZS -.88832820 04

13 JANUARY       HR    MIN  - SEC TIME-START  .16272000 07  JULIAN DATE 2410.5000
LAT(DEG)  .20319588 01  LONG(DEG) .23399444 03   V.APO(FPS) .32630938 02  V.PERI(FPS) .39580514 03
ALT(NM)   .20650086 09  APO(NM)   .33141298 09   PERI(NM)   .27319165 08  PERIOD(MIN) .10042637 10
X  .25028980 01  Y -.51279371 00 Z  .90038676-01   XD  .54622657-07   YD  .11959792-06 ZD  .48408275-07
R  .25564747 01  A -.11578527 02 D  .20183665 01    V  .14010945-06 BETA  .77136203 02 AZ  .69722338 02
A  .22205524 01  E  .84767418 00 I  .35021094 02 NODE -.91495318 01   W -.19195749 03  M -.69181979 00
R  .48418080-03  V  .18617729-03 G  .96000575-02    S -.89985430 02  SVE  .22091751 02  F  .21301805 03
ELK  .17193301 03 MLK  .16605285 03 SLK  .16558561 03  RM  .34196769 05 RS  .50682174 05      ELLIPSE
ETA  .11235350 00 ZTA -.60290693 00 RHO  .49378588 05  XP  .33786295 05      VEHICLE IS NOT ECLIPSED
XMV  .32857890 05 YMV  .21936448 04 ZMV  .92177012 04  XM  .25847233 05 YM -.14221150 05  ZM -.71058566 04
XSV  .49066594 05 YSV  .72047716 04 ZSV  .10451962 05  XS  .96385293 04 YS -.19232276 05  ZS -.83401172 04

23 JANUARY       HR    MIN  - SEC TIME-START  .16416000 07  JULIAN DATE 2420.5000
LAT(DEG)  .30606318 01  LONG(DEG) .22682088 03   V.APO(FPS) .32701436 02  V.PERI(FPS) .39572722 03
ALT(NM)   .20794066 09  APO(NM)   .33070423 09   PERI(NM)   .27325019 08  PERIOD(MIN) .10013136 10
X  .25397430 01  Y -.39759270 00 Z  .13653119 00   XD  .29654061-07   YD  .14653310-06 ZD  .58954370-07
R  .25742990 01  A -.88973476 01 D  .30401801 01    V  .16070759-06 BETA  .86521372 02 AZ  .68604166 02
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A  .22162015 01   E  .84734244 00 I    .34995800 02 NODE   -.91675030 01     W  -.19191135 03   M -.64216348 00
R  .48755663-03   V  .18730729-03 G    .29831890-02    S   -.89982098 02   SVE   .20984704 02   F  .21473732 03
ELK  .17475805 03 MLK  .17018613 03 SLK  .16383491 03  RM  .33109238 05 RS  .48272093 05          ELLIPSE
ETA  .11032966 00 ZTA -.73022666 00 RHO  .45015111 05  XP  .40030785 05          VEHICLE IS NOT ECLIPSED
XMV  .32203545 05 YMV -.78409509 03 ZMV  .76510446 04  XM  .27365772 05 YM -.85413360 04  ZM -.44487247 04
XSV  .46367548 05 YSV  .80560914 04 ZSV  .10739874 05  XS  .13201770 05 YS -.17381572 05  ZS -.75375538 04

 2 FEBRUARY      HR     MIN  - SEC TIME-START  .16560000 07  JULIAN DATE 2430.5000
LAT(DEG)  .42949750 01  LONG(DEG) .22003293 03   V.APO(FPS) .32666780 02  V.PERI(FPS) .39517166 03
ALT(NM)   .20782501 09  APO(NM)   .33151179 09   PERI(NM)   .27401191 08  PERIOD(MIN) .10050231 10
X  .25524645 01   Y -.26064557 00 Z    .19140248 00   XD  -.11263959-08    YD   .16978303-06 ZD  .67730936-07
R  .25728672 01   A -.58305630 01 D    .42663276 01    V   .18279777-06 BETA   .94165727 02 AZ  .67791942 02
A  .22216717 01   E  .84729385 00 I    .35001403 02 NODE  -.91628075 01     W  -.19200938 03  M -.58777997 00
R  .48728546-03   V  .18692777-03 G   -.40706361-02    S  -.89978877 02   SVE   .19651570 02  F  .21677367 03
ELK  .17783110 03 MLK  .17270106 03 SLK  .16189274 03  RM  .33237223 05 RS  .45748633 05          ELLIPSE
ETA  .10877091 00 ZTA -.84952214 00 RHO  .39941011 05  XP  .45050094 05          VEHICLE IS NOT ECLIPSED
XMV  .32489236 05 YMV -.31017971 04 ZMV  .62881933 04  XM  .27378461 05 YM -.30116083 04  ZM -.17988749 04
XSV  .43511132 05 YSV  .88821451 04 ZSV  .10992103 05  XS  .16356565 05 YS -.14995551 05  ZS -.65027845 04

12 FEBRUARY      HR     MIN  - SEC TIME-START  .16704000 07  JULIAN DATE 2440.5000
LAT(DEG)  .57282956 01  LONG(DEG) .21362081 03   V.APO(FPS) .32640707 02  V.PERI(FPS) .39594430 03
ALT(NM)   .20606395 09  APO(NM)   .33119867 09   PERI(NM)   .27300071 08  PERIOD(MIN) .10032837 10
X  .25363013 01   Y -.10552473 00 Z    .25293696 00   XD  -.37098512-07    YD   .18846583-06 ZD  .74310911-07
R  .25510658 01   A -.23824601 01 D    .56901984 01    V   .20595577-06 BETA   .10043757 03 AZ  .67228772 02
A  .22191076 01   E  .84768153 00 I    .35017517 02 NODE  -.91495289 01     W  -.19192736 03  M -.53647092 00
R  .48315639-03   V  .18491484-03 G   -.11560381-01    S  -.89975708 02   SVE   .18147337 02  F  .21885489 03
ELK  .17770918 03 MLK  .17360154 03 SLK  .15971863 03  RM  .34167501 05 RS  .43098957 05          ELLIPSE
ETA  .10762949 00 ZTA -.96095307 00 RHO  .34444489 05  XP  .48765101 05          VEHICLE IS NOT ECLIPSED
XMV  .33457856 05 YMV -.45224882 04 ZMV  .52475856 04  XM  .26030735 05 YM  .20474203 04  ZM  .68501556 03
XSV  .40479019 05 YSV  .96711516 04 ZSV  .11199913 05  XS  .19009573 05 YS -.12146219 05  ZS -.52673116 04

22 FEBRUARY      HR     MIN  - SEC TIME-START  .16848000 07  JULIAN DATE 2450.5000
LAT(DEG)  .73568743 01  LONG(DEG) .20761073 03   V.APO(FPS) .32714528 02  V.PERI(FPS) .39548613 03
ALT(NM)   .20260563 09  APO(NM)   .33074792 09   PERI(NM)   .27356237 08  PERIOD(MIN) .10016278 10
X  .24870663 01   Y  .63484256-01 Z    .31906429 00   XD  -.77558901-07    YD   .20181142-06 ZD  .78298097-07
R  .25082526 01   A  .14622008 01 D    .73081558 01    V   .22994309-06 BETA   .10559992 03 AZ  .66906260 02
A  .22166651 01   E  .84720001 00 I    .34993165 02 NODE  -.91721803 01     W  -.19193682 03  M -.48561633 00
R  .47504784-03   V  .18120824-03 G   -.19551048-01    S  -.89972532 02   SVE   .16531677 02  F  .22134796 03
ELK  .17378504 03 MLK  .17437520 03 SLK  .15725359 03  RM  .35427964 05 RS  .40315499 05          ELLIPSE
ETA  .10683783 00 ZTA -.10641052 01 RHO  .28832874 05  XP  .51145639 05          VEHICLE IS NOT ECLIPSED
XMV  .34785177 05 YMV -.48779217 04 ZMV  .46193094 04  XM  .23548616 05 YM  .63669360 04  ZM  .28642988 04
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XSV  .37255836 05 YSV  .10413304 05 ZSV  .11353648 05  XS  .21077957 05 YS -.89242900 04  ZS -.38700399 04

 3 MARCH          HR     MIN  - SEC TIME-START  .16992000 07  JULIAN DATE 2460.5000
LAT(DEG)   .91796355 01  LONG(DEG) .20203637 03   V.APO(FPS) .32636003 02  V.PERI(FPS) .39535560 03
ALT(NM)    .19743199 09  APO(NM)    .33170568 09    PERI(NM)    .27378639 08  PERIOD(MIN) .10057429 10
X  .24011998 01   Y  .24147420 00 Z    .38738001 00    XD  -.12176747-06    YD    .20914591-06 ZD  .79310995-07
R  .24442041 01   A  .57425845 01 D    .91192158 01     V   .25467541-06 BETA   .10982975 03 AZ  .66848009 02
A  .22227323 01   E  .84749232 00 I    .35008324 02 NODE  -.91561518 01     W  -.19200707 03  M -.43151912 00
R  .46291744-03   V  .17576118-03 G  -.28162980-01     S  -.89969293 02   SVE   .14879423 02  F  .22425054 03
ELK  .16922218 03 MLK  .17579846 03 SLK  .15440813 03  RM  .36591034 05 RS  .37381984 05          ELLIPSE
ETA  .10629925 00 ZTA -.11583388 01 RHO  .23402691 05  XP  .52224361 05         VEHICLE IS NOT ECLIPSED
XMV  .36087849 05 YMV -.40889170 04 ZMV  .44555291 04  XM  .20231958 05 YM  .97526605 04  ZM  .46304149 04
XSV  .33813796 05 YSV  .11096219 05 ZSV  .11441760 05  XS  .22506010 05 YS -.54324757 04  ZS -.23558164 04

13 MARCH          HR     MIN  - SEC TIME-START  .17136000 07  JULIAN DATE 2470.5000
LAT(DEG)   .11197061 02  LONG(DEG) .19696796 03   V.APO(FPS) .32673061 02  V.PERI(FPS) .39591427 03
ALT(NM)    .19055519 09  APO(NM)    .33086890 09    PERI(NM)    .27301994 08  PERIOD(MIN) .10019078 10
X  .22757751 01   Y  .42297761 00 Z    .45514164 00    XD  -.16902194-06    YD    .20984121-06 ZD  .76943647-07
R  .23590710 01   A  .10528904 02 D    .11123975 02     V   .28021790-06 BETA   .11324345 03 AZ  .67106899 02
A  .22170783 01   E  .84753137 00 I    .35010443 02 NODE  -.91542425 01     W  -.19190476 03  M -.38100812 00
R  .44679375-03   V  .16855702-03 G  -.37589900-01     S  -.89965952 02   SVE   .13275903 02  F  .22748969 03
ELK  .16411745 03 MLK  .17647755 03 SLK  .15106510 03  RM  .37331093 05 RS  .34280686 05          ELLIPSE
ETA  .10586767 00 ZTA -.12427634 01 RHO  .18422956 05  XP  .52088011 05         VEHICLE IS NOT ECLIPSED
XMV  .[illegible]62075 05 YMV -.21842263 04 ZMV  .47586489 04  XM  .16415912 05 YM  .12105107 05  ZM  .59166346 04
XSV  .30123170 05 YSV  .11695135 05 ZSV  .11444820 05  XS  .23254816 05 YS -.17742541 04  ZS -.76953650 03

23 MARCH          HR     MIN  - SEC TIME-START  .17280000 07  JULIAN DATE 2480.5000
LAT(DEG)   .13408743 02  LONG(DEG) .19251337 03   V.APO(FPS) .32703412 02  V.PERI(FPS) .39537872 03
ALT(NM)    .18201206 09  APO(NM)    .33095195 09    PERI(NM)    .27371248 08  PERIOD(MIN) .10025469 10
X  .21084205 01   Y  .60197421 00 Z    .51922223 00    XD  -.21874701-06    YD    .20321938-06 ZD  .70693757-07
R  .22533090 01   A  .15934550 02 D    .13322185 02     V   .30683216-06 BETA   .11591591 03 AZ  .67771108 02
A  .22180210 01   E  .84720964 00 I    .34997158 02 NODE  -.91714829 01     W  -.19196619 03  M -.32887796 00
R  .42676308-03   V  .15963769-03 G  -.48131057-01     S  -.89962527 02   SVE   .11855178 02  F  .23159580 03
ELK  .15840217 03 MLK  .17336649 03 SLK  .14703454 03  RM  .37420929 05 RS  .30995527 05          ELLIPSE
ETA  .10531032 00 ZTA -.13156340 01 RHO  .14144436 05  XP  .50856539 05         VEHICLE IS NOT ECLIPSED
XMV  .37010434 05 YMV  .70838354 03 ZMV  .54819661 04  XM  .12442274 05 YM  .13410837 05  ZM  .66963187 04
XSV  .26148363 05 YSV  .12182864 05 ZSV  .11338591 05  XS  .23304345 05 YS  .19363566 04  ZS  .83969360 03

 2 APRIL          HR     MIN  - SEC TIME-START  .17424000 07  JULIAN DATE 2490.5000
LAT(DEG)   .15807333 02  LONG(DEG) .18886039 03   V.APO(FPS) .32610947 02  V.PERI(FPS) .39551881 03
ALT(NM)    .17185699 09  APO(NM)    .33185341 09    PERI(NM)    .27358508 08  PERIOD(MIN) .10062790 10
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X  .18971785 01   Y  .77176471 00 Z    .57596839 00    XD  -.27057285-06    YD    .18833267-06 ZD   .59806890-07
R  .21275917 01   A  .22136297 02 D    .15706745 02     V   .33504585-06 BETA     .11789728 03 AZ   .68980341 02
A  .22235221 01   E  .84765858 00 I    .35010104 02 NODE  -.91510888 01      W  -.19199478 03  M -.27561411 00
R  .40295297-03   V  .14908015-03 G   -.60250787-01    S  -.89959178 02   SVE    .10825729 02  F   .23663502 03
ELK  .15194567 03 MLK  .16765929 03 SLK  .14200720 03  RM  .36706481 05 RS  .27499507 05          ELLIPSE
ETA  .10423461 00 ZTA -.13745390 01 RHO  .10755366 05  XP  .48678756 05              VEHICLE IS NOT ECLIPSED
XMV  .35859040 05 YMV  .43527775 04 ZMV  .65229077 04  XM  .86390146 04 YM  .13748856 05  ZM  .69863503 04
XSV  .21834733 05 YSV  .12512901 05 ZSV  .11085786 05  XS  .22663322 05 YS  .55887318 04  ZS  .24234724 04

12 APRIL        HR    MIN  - SEC TIME-START  .17568000 07  JULIAN DATE 2500.5000
LAT(DEG)  .18363883 02  LONG(DEG) .18627193 03   V.APO(FPS) .32720765 02  V.PERI(FPS) .39574700 03
ALT(NM)   .16014787 09  APO(NM)    .33047872 09   PERI(NM)   .27321158 08  PERIOD(MIN) .10003515 10
X  .16402928 01   Y  .92456218 00 Z    .62086057 00    XD  -.32441496-06    YD    .16347614-06 ZD   .42938206-07
R  .19826355 01   A  .29408076 02 D    .18249113 02     V   .36580486-06 BETA     .11924608 03 AZ   .70956674 02
A  .22147817 01   E  .84726615 00 I    .35004990 02 NODE  -.91618558 01      W  -.19190120 03  M -.22512585 00
R  .37549915-03   V  .13700290-03 G   -.74741406-01    S  -.89956446 02   SVE    .10501405 02  F   .24309932 03
ELK  .14454321 03 MLK  .16018582 03 SLK  .13545814 03  RM  .35102036 05 RS  .23767516 05          ELLIPSE
ETA  .10194090 00 ZTA -.14160151 01 RHO  .83452899 04  XP  .45707984 05              VEHICLE IS NOT ECLIPSED
XMV  .33194965 05 YMV  .84074438 04 ZMV  .77176487 04  XM  .52778735 04 YM  .13278033 05  ZM  .68445491 04
XSV  .17119130 05 YSV  .12606825 05 ZSV  .10625355 05  XS  .21353709 05 YS  .90786511 04  ZS  .39368428 04

22 APRIL        HR    MIN  - SEC TIME-START  .17712000 07  JULIAN DATE 2510.5000
LAT(DEG)  .20990986 02  LONG(DEG) .18518971 03   V.APO(FPS) .32662812 02  V.PERI(FPS) .39532958 03
ALT(NM)   .14690415 09  APO(NM)    .33143280 09   PERI(NM)   .27380390 08  PERIOD(MIN) .10046040 10
[illegible] 01   Y  .10503697 01 Z    .64768321 00    XD  -.38036000-06    YD    .12495203-06 ZD   .17320381-07
R  [illegible] 01   A  .38175099 02 D    .20862587 02     V   .40073275-06 BETA     .12011674 03 AZ   .74065019 02
A  .22210540 01   E  .84736732 00 I    .35002659 02 NODE  -.91662617 01      W  -.19200847 03  M -.17222410 00
R  .34444723-03   V  .12359226-03 G   -.93215257-01    S  -.89955880 02   SVE    .11449306 02  F   .25231387 03
ELK  .13588132 03 MLK  .15083860 03 SLK  .12635448 03  RM  .32563926 05 RS  .19781381 05          ELLIPSE
ETA  .97099974-01 ZTA -.14345025 01 RHO  .69010387 04  XP  .42062260 05              VEHICLE IS NOT ECLIPSED
XMV  .28773388 05 YMV  .12428191 05 ZMV  .88341096 04  XM  .25617432 04 YM  .12208083 05  ZM  .63572095 04
XSV  .11916340 05 YSV  .12334810 05 ZSV  .98567908 04  XS  .19418791 05 YS  .12301464 05  ZS  .53345283 04

2 MAY           HR    MIN  - SEC TIME-START  .17856000 07  JULIAN DATE 2520.5000
LAT(DEG)  .23447048 02  LONG(DEG) .18623971 03   V.APO(FPS) .32590916 02  V.PERI(FPS) .39559815 03
ALT(NM)   .13197898 09  APO(NM)    .33201139 09   PERI(NM)   .27349230 08  PERIOD(MIN) .10069039 10
X  .98278297 00   Y  .11339687 01 Z    .64646631 00    XD  -.43696016-06    YD    .63532269-07 ZD  -.23487171-07
R  .16339112 01   A  .49085325 02 D    .23306874 02     V   .44217890-06 BETA     .12104366 03 AZ   .78942201 02
A  .22244425 01   E  .84777325 00 I    .35006615 02 NODE  -.91512811 01      W  -.19197821 03  M -.11991939 00
R  .30945288-03   V  .10905785-03 G   -.11980543 00    S  -.89961822 02   SVE    .15112192 02  F   .26618751 03
ELK  .12548577 03 MLK  .13908915 03 SLK  .11243831 03  RM  .29054555 05 RS  .15552197 05          ELLIPSE
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ETA  .86980675-01 ZTA -.14219629 01 RHO  .63908558 04  XP  .37756210 05              VEHICLE IS NOT ECLIPSED
XMV  .22438708 05 YMV  .15807792 05 ZMV  .95281301 04  XM  .61232861 03 YM  .10789285 05  ZM  .56346468 04
XSV  .61277703 04 YSV  .11428754 05 ZSV  .85851536 04  XS  .16923267 05 YS  .15168323 05  ZS  .65776234 04

12 MAY           HR     MIN   - SEC TIME-START  .18000000 07  JULIAN DATE 2530.5000
LAT(DEG)  .25082208 02  LONG(DEG) .19029805 03   V.APO(FPS) .32794253 02  V.PERI(FPS) .39560714 03
ALT(NM)   .11465890 09  APO(NM)   .32978923 09   PERI(NM)   .27335054 08  PERIOD(MIN) .99751961 09
X  .58439929 00  Y  .11468692 01 Z    .59843825 00   XD  -.47929934-06   YD  -.44903380-07 ZD -.94735823-07
R  .14194928 01  A  .62998403 02 D    .24934756 02   V    .49063127-06 BETA   .12388551 03 AZ  .86804692 02
A  .22105999 01  E  .84689940 00 I    .35006231 02 NODE -.91646843 01    W    .16809492 03  M -.68770379-01
R  .26884333-03  V  .93460673-04 G   -.16770312 00    S  -.89986080 02  SVE   .26377542 02  F -.69385233 02
ELK  .11269991 03 MLK  .12395944 03 SLK  .87948901 02  RM  .24475484 05 RS  .11293501 05          ELLIPSE
ETA  .65382439-01 ZTA -.13677232 01 RHO  .68922077 04  XP  .32540184 05              VEHICLE IS NOT ECLIPSED
XMV  .14254407 05 YMV  .17621149 05 ZMV  .92388478 04  XM -.54740356 03 YM  .92785073 04  ZM  .47974379 04
XSV -.23197668 03 YSV  .92993752 04 ZSV  .64039813 04  XS  .13938980 05 YS  .17600281 05  ZS  .76323043 04

[illegible] MAY          HR     MIN   - SEC TIME-START  .18144000 07  JULIAN DATE 2540.5000
LAT(DEG)  .24264760 02  LONG(DEG) .19726912 03   V.APO(FPS) .32672272 02  V.PERI(FPS) .39558742 03
ALT(NM)   .92817941 08  APO(NM)   .33113004 09   PERI(NM)   .27345462 08  PERIOD(MIN) .10031862 10
X  .18518655 00  Y  .10322938 01 Z    .46959773 00   XD  -.40828376-06   YD  -.22927459-06 ZD -.20560569-06
R  .11491068 01  A  .79829701 02 D    .24120888 02   V    .51140606-06 BETA   .13408358 03 AZ  .10034499 03
A  .22189637 01  E  .84741841 00 I    .35004460 02 NODE -.91622181 01    W    .16803704 03  M -.16301632-01
R  .21763387-03  V  .76117199-04 G   -.26781411 00    S   .26995034 03  SVE   .58744497 02  F -.20868014 02
ELK  .97455517 02 MLK  .10473256 03 SLK  .39487546 02  RM  .18540646 05 RS  .81875408 04          ELLIPSE
ETA  .17513836-01 ZTA -.12722577 01 RHO  .78192178 04  XP  .25756025 05              VEHICLE IS NOT ECLIPSED
XMV  .53192852 04 YMV  .16301114 05 ZMV  .70522656 04  XM -.97576044 03 YM  .79111930 04  ZM  .39620835 04
XSV -.62130381 04 YSV  .46850776 04 ZSV  .25463759 04  XS  .10556563 05 YS  .19527229 05  ZS  .84679733 04

1 JUNE           HR     MIN   - SEC TIME-START  .18288000 07  JULIAN DATE 2550.5000
LAT(DEG)  .19278413 02  LONG(DEG) .20193018 03   V.APO(FPS) .32438946 02  V.PERI(FPS) .39567755 03
ALT(NM)   .67263658 08  APO(NM)   .33362335 09   PERI(NM)   .27348377 08  PERIOD(MIN) .10136827 10
X -.59603072-01  Y  .78436571 00 Z    .27329820 00   XD  -.15930489-06   YD  -.30376624-06 ZD -.22066405-06
R  .83275086 00  A  .94345490 02 D    .19158785 02   V    .40785365-06 BETA   .14833403 03 AZ  .12185407 03
A  .22344151 01  E  .84845739 00 I    .35002353 02 NODE -.91606128 01    W    .16806449 03  M  .35348207-01
R  .15771796-03  V  .57181049-04 G   -.34783244 00    S   .26988677 03  SVE   .10695593 03  F  .42704406 02
ELK  .83676847 02 MLK  .84633452 02 SLK  .24113656 02  RM  .11950423 05 RS  .90425054 04          ELLIPSE
ETA -.73714066-01 ZTA -.12058461 01 RHO  .70136870 04  XP  .18196154 05              VEHICLE IS NOT ECLIPSED
XMV -.58983848 03 YMV  .11506040 05 ZMV  .31742317 04  XM -.80814324 03 YM  .68911477 04  ZM  .32359395 04
XSV -.82738224 04 YSV -.25039565 04 ZSV -.26534825 04  XS  .68758406 04 YS  .20901145 05  ZS  .90636537 04

11 JUNE          HR     MIN   - SEC TIME-START  .18432000 07  JULIAN DATE 2560.5000
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LAT(DEG)  .11013791 02  LONG(DEG) .20190353 03   V.APO(FPS) .32614601 02  V.PERI(FPS) .39558245 03
ALT(NM)   .46196467 08  APO(NM)   .33176409 09   PERI(NM)   .27349806 08  PERIOD(MIN) .10058671 10
X -.13750042 00  Y  .54445188 00 Z   .10856212 00   XD  -.46123939-07   YD  -.25025934-06 ZD -.16260679-06
R  .57194401 00  A  .10417358 03 D   .10941841 02    V   .30199027-06 BETA   .14868826 03 AZ  .13751506 03
A  .22229153 01  E  .84766546 00 I   .35006434 02 NODE  -.91519619 01    W   .16804995 03  M  .87552130-01
R  .10832273-03  V  .40844102-04 G  -.36193502 00    S   .26983763 03  SVE   .13016942 03  F  .80376104 02
ELK  .73255745 02 MLK  .61339075 02 SLK  .61777884 02  RM  .70704390 04 RS  .12853479 05        ELLIPSE
ETA -.20604615 00 ZTA -.11964730 01 RHO  .54724940 04  XP  .12221848 05       VEHICLE IS NOT ECLIPSED
XMV -.29804104 04 YMV  .64096551 04 ZMV -.15678802 03  XM -.24464267 03 YM  .63603877 04  ZM  .27030973 04
XSV -.62233047 04 YSV -.89142047 04 ZSV -.68570655 04  XS  .29982516 04 YS  .21684248 05  ZS  .94033748 04

21 JUNE        HR     MIN  - SEC TIME-START  .18576000 07  JULIAN DATE 2570.5000
LAT(DEG) -.23034650 01  LONG(DEG) .20318025 03   V.APO(FPS) .32647527 02  V.PERI(FPS) .39575670 03
ALT(NM)   .30848107 08  APO(NM)   .33126920 09   PERI(NM)   .27324540 08  PERIOD(MIN) .10036826 10
X -.16312313 00  Y  .34501107 00 Z  -.15248208-01   XD  -.19462054-07   YD  -.21611698-06 ZD -.12804023-06
R  .38193493 00  A  .11530504 03 D  -.22880603 01    V   .25195163-06 BETA   .13618391 03 AZ  .14091800 03
A  .22[illegible]957 01  E  .84758541 00 I   .35005184 02 NODE  -.91664542 01    W   .16799820 03  M  .13976952 00
R  .72336161-04  V  .27719787-04 G  -.37577395 00    S   .26972011 03  SVE   .12908419 03  F  .99881474 02
ELK  .60912786 02 MLK  .31884895 02 SLK  .81219636 02  RM  .54018550 04 RS  .17156244 05        ELLIPSE
ETA -.40718147 00 ZTA -.11273946 01 RHO  .49683878 04  XP  .74303547 04       VEHICLE IS NOT ECLIPSED
XMV -.43110367 04 YMV  .16993222 04 ZMV -.27762032 04  XM  .48500653 03 YM  .63928641 04  ZM  .24185587 04
XSV -.28637480 04 YSV -.13762610 05 ZSV -.98349506 04  XS -.96228220 03 YS  .21854796 05  ZS  .94773059 04

1 JULY         HR     MIN  - SEC TIME-START  .18720000 07  JULIAN DATE 2580.5000
LAT(DEG) -.26206299 02  LONG(DEG) .21497650 03   V.APO(FPS) .32508087 02  V.PERI(FPS) .39559678 03
ALT(NM)   .21678989 08  APO(NM)   .33292281 09   PERI(NM)   .27354705 08  PERIOD(MIN) .10107599 10
X -.17625258 00  Y  .16457965 00 Z  -.11789690 00   XD  -.11995055-07   YD  -.20428504-06 ZD -.11171265-06
R  .25842338 00  A  .13696152 03 D  -.26054121 02    V   .23314368-06 BETA   .10703777 03 AZ  .13504530 03
A  .22301180 01  E  .84813026 00 I   .35004580 02 NODE  -.91636208 01    W  -.19192071 03  M  .19038340 00
R  .50837762-04  V  .17427660-04 G  -.22457216 00    S   .26948138 03  SVE   .10627084 03  F  .11150449 03
ELK  .43734911 02 MLK  .47817492 02 SLK  .92926059 02  RM  .80197112 04 RS  .21305118 05        ELLIPSE
ETA -.70351440 00 ZTA -.74019407 00 RHO  .53832886 04  XP  .32379678 04       VEHICLE IS NOT ECLIPSED
XMV -.52656205 04 YMV -.31347216 04 ZMV -.51732513 04  XM  .11316409 04 YM  .69949142 04  ZM  .24079959 04
XSV  .76142682 03 YSV -.17552871 05 ZSV -.12050934 05  XS -.48954065 04 YS  .21413064 05  ZS  .92856785 04

11 JULY 1964   HR     MIN  - SEC TIME-START  .18864000 07  JULIAN DATE 2590.5000
LAT(DEG) -.49004775 02  LONG(DEG) .25171766 03   V.APO(FPS) .32629827 02  V.PERI(FPS) .39551474 03
ALT(NM)   .22639825 08  APO(NM)   .33164993 09   PERI(NM)   .27357843 08  PERIOD(MIN) .10054213 10
X -.18423608 00  Y -.11435941-01 Z  -.21096116 00   XD  -.62018195-08   YD  -.20455897-06 ZD -.10481042-06
R  .28031826 00  A  .18355192 03 D  -.48814129 02    V   .22993055-06 BETA   .66604662 02 AZ  .10505745 03
A  .22222584 01  E  .84757566 00 I   .35002850 02 NODE  -.91487299 01    W  -.19195802 03  M  .24343437 00
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R  .53090579-04  V  .13256332-04 G   .39461580 00    S   .26976305 03  SVE   .70671813 02  F  .11950684 03
ELK  .45423197 02 MLK  .63229342 02 SLK  .10090329 03  RM  .12695077 05 RS  .25197297 05       ELLIPSE
ETA -.73990605 00 ZTA  .10040516 00 RHO  .65580505 04  XP -.48672044 03          VEHICLE IS NOT ECLIPSED
XMV -.57755735 04 YMV -.83615961 04 ZMV -.76086435 04  XM  .14543420 04 YM  .80933676 04  ZM  .26605790 04
XSV  .43718588 04 YSV -.20636774 05 ZSV -.13780936 05  XS -.86930903 04 YS  .20368545 05  ZS  .88328717 04

21 JULY          HR    MIN  - SEC TIME-START  .19008000 07  JULIAN DATE 2600.5000
LAT(DEG) -.48626152 02  LONG(DEG) .28399313 03   V.APO(FPS) .32597243 02  V.PERI(FPS) .39588759 03
ALT(NM)   .32425931 08  APO(NM)   .33171780 09   PERI(NM)   .27310365 08  PERIOD(MIN) .10055070 10
X -.18607158 00  Y -.19059224 00 Z  -.30038054 00   XD   .26127194-08   YD  -.21079515-06 ZD -.10273489-06
R  .40146794 00  A  .22568762 03 D  -.48435175 02   V    .23451200-06 BETA   .41467057 02 AZ  .73799156 02
A  .22223847 01  E  .84784879 00 I   .35008669 02 NODE  -.91758393 01    W  -.19199330 03  M  .29522112 00
R  .76035594-04  V  .19274229-04 G   .52237314 00    S  -.89871202 02  SVE   .49504644 02  F  .12545567 03
ELK  .61270406 02 MLK  .72871986 02 SLK  .10679464 03  RM  .18216159 05 RS  .28838411 05       ELLIPSE
ETA -.52078378 00 ZTA  .46736215 00 RHO  .86836479 04  XP -.36799708 04          VEHICLE IS NOT ECLIPSED
XMV -.56154146 04 YMV -.14023806 05 ZMV -.10179805 05  XM  .12511317 04 YM  .95534921 04  ZM  .31344216 04
XSV  .78797615 04 YSV -.23221332 05 ZSV -.15176727 05  XS -.12244044 05 YS  .18751018 05  ZS  .81313436 04

31 JULY          HR    MIN  - SEC TIME-START  .19152000 07  JULIAN DATE 2610.5000
LAT(DEG) -.43245533 02  LONG(DEG) .29307828 03   V.APO(FPS) .32539982 02  V.PERI(FPS) .39543631 03
ALT(NM)   .46042518 08  APO(NM)   .33269641 09   PERI(NM)   .27374030 08  PERIOD(MIN) .10098886 10
X -.17848635 00  Y -.37635768 00 Z  -.38915416 00   XD   .15681513-07   YD  -.21939039-06 ZD -.10300670-06
R  .57003810 00  A  .24462751 03 D  -.43053498 02   V    .24287534-06 BETA   .30036277 02 AZ  .62852515 02
A  .22288362 01  E  .84793559 00 I   .35002748 02 NODE  -.91555461 01    W  -.19190905 03  M  .34565309 00
[illegible] 03  V  .30265467-04 G   .39803117 00    S  -.89894989 02  SVE   .40812035 02  F  .12995915 03
ELK  .71660819 02 MLK  .80264914 02 SLK  .11139898 03  RM  .24236838 05 RS  .32256160 05       ELLIPSE
ETA -.37217723 00 ZTA  .52142815 00 RHO  .11871519 05  XP -.62039791 04          VEHICLE IS NOT ECLIPSED
XMV -.45502529 04 YMV -.20015278 05 ZMV -.12888296 05  XM  .36388043 03 YM  .11187862 05  ZM  .37607397 04
XSV  .11264717 05 YSV -.25434648 05 ZSV -.16329259 05  XS -.15451089 05 YS  .16607231 05  ZS  .72017026 04

10 AUGUST        HR    MIN  - SEC TIME-START  .19296000 07  JULIAN DATE 2620.5000
LAT(DEG) -.39184123 02  LONG(DEG) .29311590 03   V.APO(FPS) .32635927 02  V.PERI(FPS) .39559397 03
ALT(NM)   .61435976 08  APO(NM)   .33152186 09   PERI(NM)   .27346911 08  PERIOD(MIN) .10048374 10
X -.15772234 00  Y -.56970730 00 Z  -.47862089 00   XD   .33081768-07   YD  -.22803796-06 ZD -.10414476-06
R  .76060548 00  A  .25452535 03 D  -.38995768 02   V    .25286725-06 BETA   .24836798 02 AZ  .60811075 02
A  .22213980 01  E  .84757754 00 I   .35002779 02 NODE  -.91545110 01    W  -.19197691 03  M  .39950263 00
R  .14405407-03  V  .43012284-04 G   .30567418 00    S  -.89931000 02  SVE   .36917766 02  F  .13377293 03
ELK  .78458940 02 MLK  .86710782 02 SLK  .11514575 03  RM  .30560936 05 RS  .35471866 05       ELLIPSE
ETA -.28307774 00 ZTA  .47918973 00 RHO  .16032162 05  XP -.78979047 04          VEHICLE IS NOT ECLIPSED
XMV -.24049256 04 YMV -.26126612 05 ZMV -.15671225 05  XM -.12944298 04 YM  .12764207 05  ZM  .44452390 04
XSV  .14522972 05 YSV -.27354418 05 ZSV -.17293710 05  XS -.18222328 05 YS  .13992013 05  ZS  .60677245 04
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20 AUGUST        HR     MIN  - SEC TIME-START  .19440000 07  JULIAN DATE 2630.5000
LAT(DEG) -.36322908 02  LONG(DEG) .28986937 03   V.APO(FPS) .32563508 02  V.PERI(FPS) .39595152 03
ALT(NM)    .77942885 08  APO(NM)    .33203807 09   PERI(NM)    .27304032 08  PERIOD(MIN) .10068261 10
X -.12018616 00  Y -.76996055 00 Z   -.56908549 00   XD   .54414385-07   YD  -.23514835-06 ZD -.10518522-06
R  .96495713 00  A  .26112807 03 D  -.36139417 02    V   .26328616-06 BETA   .22703170 02 AZ  .62370742 02
A  .22243279 01  E  .84801696 00 I   .35012071 02 NODE -.91794797 01    W  -.19197757 03  M   .45029047 00
R  .18275703-03  V  .56732226-04 G   .24528279 00    S  -.89952409 02  SVE  .34719483 02  F   .13692945 03
ELK  .83579100 02 MLK  .92706858 02 SLK  .11828117 03  RM  .37023146 05 RS  .38509162 05        ELLIPSE
ETA -.22551284 00 ZTA  .40086093 00 RHO  .20971143 05  XP -.86080029 04          VEHICLE IS NOT ECLIPSED
XMV  .90997528 03 YMV -.32097295 05 ZMV -.18429569 05  XM -.37289249 04 YM  .14037978 05  ZM  .50817488 04
XSV  .17654902 05 YSV -.29039753 05 ZSV -.18109466 05  XS -.20473851 05 YS  .10980436 05  ZS  .47616455 04

30 AUGUST        HR     MIN  - SEC TIME-START  .19584000 07  JULIAN DATE 2640.5000
LAT(DEG) -.34217954 02  LONG(DEG) .28519977 03   V.APO(FPS) .32579568 02  V.PERI(FPS) .39524773 03
ALT(NM)    .95261798 08  APO(NM)    .33240787 09   PERI(NM)    .27396631 08  PERIOD(MIN) .10087700 10
X -.62748082-01  Y -.97526670 00 Z   -.66015937 00   XD   .79027148-07   YD  -.23957045-06 ZD -.10546223-06
R  .11793612 01  A  .26631869 03 D  -.34039209 02    V   .27342562-06 BETA   .22319650 02 AZ  .65177243 02
A  .22271901 01  E  .84769757 00 I   .34997209 02 NODE -.91444542 01    W  -.19191124 03  M   .50140586 00
R  .22336386-03  V  .71168741-04 G   .20363012 00    S  -.89964904 02  SVE  .33096470 02  F   .13952378 03
ELK  .87883810 02 MLK  .93467244 02 SLK  .12097052 03  RM  .43457563 05 RS  .41388794 05        ELLIPSE
ETA -.18560708 00 ZTA  .30626193 00 RHO  .26456591 05  XP -.81966818 04          VEHICLE IS NOT ECLIPSED
XMV  .53963724 04 YMV -.37638637 05 ZMV -.21042148 05  XM -.63681199 04 YM  .14763893 05  ZM  .55582019 04
XSV  .20670937 05 YSV -.30531087 05 ZSV -.18804186 05  XS -.22142684 05 YS  .76563433 04  ZS  .33202402 04

 9 SEPTEMBER     HR     MIN  - SEC TIME-START  .19728000 07  JULIAN DATE 2650.5000
LAT(DEG) -.32580793 02  LONG(DEG)-.80146105 02   V.APO(FPS) .32621992 02  V.PERI(FPS) .39578112 03
ALT(NM)    .11318633 09  APO(NM)    .33152939 09   PERI(NM)    .27322927 08  PERIOD(MIN) .10047683 10
X  .17086743-01  Y -.11829179 01 Z   -.75096641 00   XD   .10611603-06   YD  -.24045771-06 ZD -.10450145-06
R  .14012627 01  A -.89172443 02 D  -.32405405 02    V   .28284461-06 BETA   .23037181 02 AZ  .68009089 02
A  .22212962 01  E  .84770422 00 I   .35007002 02 NODE -.91651498 01    W  -.19199147 03  M   .55539834 00
R  .26539067-03  V  .86165221-04 G   .17307731 00    S  -.89972439 02  SVE  .31614955 02  F   .14196927 03
ELK  .91770085 02 MLK  .10407464 03 SLK  .12331882 03  RM  .49695386 05 RS  .44122029 05        ELLIPSE
ETA -.15645264 00 ZTA  .20330402 00 RHO  .32235641 05  XP -.65548910 04          VEHICLE IS NOT ECLIPSED
XMV  .10951145 05 YMV -.42463247 05 ZMV -.23378977 05  XM -.10550378 05 YM  .14718072 05  ZM  .57651648 04
XSV  .23575042 05 YSV -.31855244 05 ZSV -.19396242 05  XS -.23174275 05 YS  .41100701 04  ZS  .17824304 04

19 SEPTEMBER     HR     MIN  - SEC TIME-START  .19872000 07  JULIAN DATE 2660.5000
LAT(DEG) -.31235960 02  LONG(DEG) .27415670 03   V.APO(FPS) .32546865 02  V.PERI(FPS) .39588038 03
ALT(NM)    .13153374 09  APO(NM)    .33227593 09   PERI(NM)    .27314535 08  PERIOD(MIN) .10078700 10
X  .12107465 00  Y -.13895852 01 Z   -.84028467 00   XD   .13477929-06   YD  -.23721170-06 ZD -.10197088-06
R  .16283993 01  A -.35020389 02 D  -.31065576 02    V   .29126089-06 BETA   .24487148 02 AZ  .70330733 02
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A   .22258652 01  E   .84806351 00 I    .35011788 02 NODE  -.91751827 01     W   -.19195575 03  M   .60511777 00
R   .30840896-03  V   .10160087-03 G    .14947746 00     S  -.89977084 02  SVE    .30098741 02  F   .14401942 03
ELK  .95433756 02 MLK  .10955891 03 SLK  .12539647 03  RM  .55579069 05 RS  .46725085 05          ELLIPSE
ETA -.13431315 00 ZTA  .95786102-01 RHO  .38037791 05  XP -.36199517 04            VEHICLE IS NOT ECLIPSED
XMV  .17380530 05 YMV -.46323095 05 ZMV -.25320366 05  XM -.14540742 05 YM  .13730569 05  ZM  .56116067 04
XSV  .26372955 05 YSV -.33039248 05 ZSV -.19902486 05  XS -.23533166 05 YS  .44672192 03  ZS  .19372656 03

29 SEPTEMBER    HR    MIN  - SEC TIME-START  .20016000 07  JULIAN DATE 2670.5000
LAT(DEG) -.30073511 02  LONG(DEG) .26824960 03   V.APO(FPS) .32614659 02  V.PERI(FPS) .39514723 03
ALT(NM)    .15012442 09  APO(NM)    .33210100 09   PERI(NM)    .27407790 08  PERIOD(MIN) .10075267 10
X   .25015670 00  Y -.15915174 01 Z   -.92665691 00    XD    .16403600-06    YD  -.22945009-06 ZD -.97654728-07
R   .18585475 01  A -.81067262 02 D   -.29906890 02     V    .29848215-06 BETA    .26443904 02 AZ  .72005213 02
A   .22253597 01  E   .84751022 00 I    .34993356 02 NODE  -.91404915 01     W   -.19192548 03  M   .65765971 00
R   .35199763-03  V   .11735610-03 G    .13048058 00     S  -.89979950 02  SVE    .28485194 02  F   .14582616 03
ELK  .98976738 02 MLK  .11492652 03 SLK  .12726190 03  RM  .60954382 05 RS  .49209185 05          ELLIPSE
ETA -.11700307 00 ZTA -.14604335-01 RHO  .43583442 05  XP  .63227821 03            VEHICLE IS NOT ECLIPSED
XMV  .24416016 05 YMV -.49020413 05 ZMV -.26763669 05  XM -.18548626 05 YM  .11691595 05  ZM  .50290610 04
XSV  .29074533 05 YSV -.34093960 05 ZSV -.20334116 05  XS -.23207143 05 YS -.32298569 04  ZS -.14004917 04

9 OCTOBER    HR    MIN  - SEC TIME-START  .20160000 07  JULIAN DATE 2680.5000
LAT(DEG) -.29021913 02  LONG(DEG) .26222387 03   V.APO(FPS) .32595737 02  V.PERI(FPS) .39599844 03
ALT(NM)    .16877611 09  APO(NM)    .33164850 09   PERI(NM)    .27295755 08  PERIOD(MIN) .10051545 10
X   .40440506 00  Y -.17847194 01 Z   -.10084834 01    XD    .19286283-06    YD  -.21698856-06 ZD -.91436967-07
R   .20894510 01  A -.77232767 02 D   -.28858930 02     V    .30436955-06 BETA    .28768112 02 AZ  .73080354 02
A   .22218653 01  E   .84789463 00 I    .35013258 02 NODE  -.91753443 01     W   -.19199630 03  M   .71089181 00
R   .39572936-03  V   .13330738-03 G    .11467567 00     S  -.89981675 02  SVE    .26752812 02  F   .14761483 03
ELK  .10245361 03 MLK  .12015923 03 SLK  .12895120 03  RM  .65678699 05 RS  .51580146 05          ELLIPSE
ETA -.10315939 00 ZTA -.12701153 00 RHO  .48587481 05  XP  .61748293 04            VEHICLE IS NOT ECLIPSED
XMV  .31722041 05 YMV -.50434767 05 ZMV -.27635811 05  XM -.22236777 05 YM  .85744219 04  ZM  .39819734 04
XSV  .31681039 05 YSV -.35047703 05 ZSV -.20699651 05  XS -.22195775 05 YS -.68125518 04  ZS -.29541870 04

19 OCTOBER    HR    MIN  - SEC TIME-START  .20304000 07  JULIAN DATE 2690.5000
LAT(DEG) -.28033218 02  LONG(DEG) .25612623 03   V.APO(FPS) .32553388 02  V.PERI(FPS) .39563925 03
ALT(NM)    .18730307 09  APO(NM)    .33239137 09   PERI(NM)    .27346161 08  PERIOD(MIN) .10084884 10
X   .58300357 00  Y -.19651220 01 Z   -.10841054 01    XD    .22023113-06    YD  -.19984062-06 ZD -.83296624-07
R   .23188105 01  A -.73475666 02 D   -.27873857 02     V    .30883062-06 BETA    .31374729 02 AZ  .73663943 02
A   .22267756 01  E   .84794980 00 I    .35005666 02 NODE  -.91631335 01     W   -.19193387 03  M   .76003596 00
R   .43916866-03  V   .14932450-03 G    .10117572 00     S  -.89982645 02  SVE    .24897058 02  F   .14908468 03
ELK  .10589369 03 MLK  .12523021 03 SLK  .13049348 03  RM  .69634498 05 RS  .53850193 05          ELLIPSE
ETA -.91887005-01 ZTA -.24078246 00 RHO  .52770688 05  XP  .12914642 05            VEHICLE IS NOT ECLIPSED
XMV  .38936426 05 YMV -.50539887 05 ZMV -.27904085 05  XM -.25262159 05 YM  .44482241 04  ZM  .24765439 04
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XSV  .34199377 05 YSV -.35901123 05 ZSV -.21008457 05  XS -.20525110 05 YS -.10190540 05  ZS -.44190842 04

29 OCTOBER        HR     MIN  - SEC TIME-START  .20448000 07  JULIAN DATE 2700.5000
LAT(DEG) -.27074732 02  LONG(DEG) .24997689 03   V.APO(FPS) .32630885 02  V.PERI(FPS) .39522207 03
ALT(NM)   .20551772 09  APO(NM)    .33186521 09   PERI(NM)    .27396767 08  PERIOD(MIN) .10064894 10
X   .78425125 00  Y -.21287530 01 Z   -.11518860 01   XD    .24512487-06    YD   -.17821588-06 ZD -.73304870-07
R   .25443036 01  A -.69775760 02 D   -.26919061 02    V    .31180235-06 BETA    .34210730 02 AZ   .73867354 02
A   .22238320 01  E   .84746683 00 I    .34994181 02 NODE  -.91446161 01      W   -.19194760 03  M   .81411412 00
R   .48187568-03  V   .16527003-03 G    .89396293-01     S  -.89983110 02  SVE    .22931750 02   F   .15050568 03
ELK  .10931201 03 MLK  .13010493 03 SLK  .13191591 03  RM  .72721444 05 RS  .56024291 05           ELLIPSE
ETA -.82572967-01 ZTA -.35576289 00 RHO  .55868269 05  XP   .20714762 05              VEHICLE IS NOT ECLIPSED
XMV  .45694037 05 YMV -.49397314 05 ZMV -.27574787 05  XM -.27299534 05 YM -.53228955 03  ZM  .55746118 03
XSV  .36635897 05 YSV -.36664971 05 ZSV -.21265282 05  XS -.18241394 05 YS -.13264632 05  ZS -.57520439 04

 8 NOVEMBER       HR     MIN  - SEC TIME-START  .20592000 07  JULIAN DATE 2710.5000
LAT(DEG) -.26124166 02  LONG(DEG) .24376756 03   V.APO(FPS) .32567622 02  V.PERI(FPS) .39616702 03
ALT(NM)   .22323258 09  APO(NM)    .33182605 09   PERI(NM)    .27275197 08  PERIOD(MIN) .10058140 10
X   .10055889 01  Y -.22719009 01 Z   -.12102867 01   XD    .26658309-06    YD   -.15250597-06 ZD -.61615976-07
R   .27636093 01  A -.66124857 02 D   -.25972325 02    V    .31324294-06 BETA    .37245570 02 AZ   .73787432 02
A   .22228371 01  E   .84807562 00 I    .35018496 02 NODE  -.91812584 01      W   -.19199106 03  M   .86593255 00
R   .52341086-03  V   .18099930-03 G    .78937968-01     S  -.89983242 02  SVE    .20865585 02   F   .15189581 03
ELK  .11271494 03 MLK  .13473287 03 SLK  .13323257 03  RM  .74868934 05 RS  .58106801 05           ELLIPSE
ETA -.74783190-01 ZTA -.47184803 00 RHO  .57641372 05  XP   .29380524 05              VEHICLE IS NOT ECLIPSED
XMV  .51651742 05 YMV -.47165894 05 ZMV -.26698939 05  XM -.28065795 05 YM -.61212236 04  ZM -.16881665 04
XSV  .38990420 05 YSV -.37348989 05 ZSV -.21475579 05  XS -.15404473 05 YS -.15938129 05  ZS -.69115261 04

18 NOVEMBER       HR     MIN  - SEC TIME-START  .20736000 07  JULIAN DATE 2720.5000
LAT(DEG) -.25166616 02  LONG(DEG) .23751057 03   V.APO(FPS) .32580038 02  V.PERI(FPS) .39529171 03
ALT(NM)   .24026260 09  APO(NM)    .33236855 09   PERI(NM)    .27390737 08  PERIOD(MIN) .10085799 10
X   .12436681 01  Y -.23912680 01 Z   -.12579360 01   XD    .28374448-06    YD   -.12327606-06 ZD -.48462934-07
R   .29744371 01  A -.62521630 02 D   -.25018803 02    V    .31313986-06 BETA    .40464001 02 AZ   .73502761 02
A   .22269103 01  E   .84771120 00 I    .34995687 02 NODE  -.91487476 01      W   -.19191949 03  M   .91541275 00
R   .56334035-03  V   .19636095-03 G    .69519156-01     S  -.89983159 02  SVE    .18714842 02   F   .15302459 03
ELK  .11610354 03 MLK  .13905706 03 SLK  .13445956 03  RM  .76045201 05 RS  .60107082 05           ELLIPSE
ETA -.68201383-01 ZTA -.58879057 00 RHO  .57896625 05  XP   .38654316 05              VEHICLE IS NOT ECLIPSED
XMV  .56531484 05 YMV -.44085373 05 ZMV -.25368166 05  XM -.27361422 05 YM -.12001482 05  ZM -.41365481 04
XSV  .41270410 05 YSV -.37961972 05 ZSV -.21644936 05  XS -.12100349 05 YS -.18124884 05  ZS -.78597773 04

28 NOVEMBER       HR     MIN  - SEC TIME-START  .20880000 07  JULIAN DATE 2730.5000
LAT(DEG) -.24192651 02  LONG(DEG) .23120863 03   V.APO(FPS) .32625541 02  V.PERI(FPS) .39545940 03
ALT(NM)   .25642834 09  APO(NM)    .33173969 09   PERI(NM)    .27365483 08  PERIOD(MIN) .10058305 10
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X  .14944480 01  Y -.24841169 01 Z  -.12936968 01    XD   .29587209-06    YD  -.91255000-07 ZD -.34152568-07
R  .31745650 01  A -.58968829 02 D  -.24049101 02     V   .31150308-06 BETA   .43858781 02 AZ  .73074889 02
A  .22228614 01  E  .84757445 00 I   .35001117 02 NODE  -.91558654 01     W  -.19196806 03  M  .97041753 00
R  .60124337-03  V  .21119874-03 G   .60935810-01     S  -.89982952 02  SVE   .16497214 02  F  .15423033 03
ELK  .11947536 03 MLK  .14300924 03 SLK  .13561088 03  RM  .76249371 05 RS  .62026077 05          ELLIPSE
ETA -.62591599-01 ZTA -.70665478 00 RHO  .56484010 05  XP  .48251041 05          VEHICLE IS NOT ECLIPSED
XMV  .60131602 05 YMV -.40451122 05 ZMV -.23703670 05  XM -.25079533 05 YM -.17813493 05  ZM -.66398079 04
XSV  .43478358 05 YSV -.38505907 05 ZSV -.21775255 05  XS -.84262891 04 YS -.19758707 05  ZS -.85682234 04

 8 DECEMBER      HR     MIN  - SEC TIME-START  .21024000 07  JULIAN DATE 2740.5000
LAT(DEG) -.23197032 02  LONG(DEG) .22485099 03   V.APO(FPS) .32548404 02  V.PERI(FPS) .39618895 03
ALT(NM)    .27155883 09   APO(NM)    .33201988 09   PERI(NM)    .27273514 08  PERIOD(MIN) .10066214 10
X  .17533178 01  Y -.25483985 01 Z  -.13167226 01    XD   .30239088-06    YD  -.57299154-07 ZD -.19048320-07
R  .33618770 01  A -.55471729 02 D  -.23058012 02     V   .30836063-06 BETA   .47430598 02 AZ  .72551807 02
A  .22240264 01  E  .84816623 00 I   .35019118 02 NODE  -.91798844 01     W  -.19197615 03  M  .10205778 01
R  .63671912-03  V  .22535371-03 G   .53037779-01     S  -.89982685 02  SVE   .14224476 02  F  .15533960 03
ELK  .12282542 03 MLK  .14650296 03 SLK  .13669240 03  RM  .75527059 05 RS  .63868683 05          ELLIPSE
ETA -.57774095-01 ZTA -.82542473 00 RHO  .53315529 05  XP  .57846865 05          VEHICLE IS NOT ECLIPSED
XMV  .62346226 05 YMV -.36602706 05 ZMV -.21852384 05  XM -.21222403 05 YM -.23169624 05  ZM -.90311614 04
XSV  .45614657 05 YSV -.38989362 05 ZSV -.21871017 05  XS -.44908330 04 YS -.20782969 05  ZS -.90125283 04

18 DECEMBER      HR     MIN  - SEC TIME-START  .21168000 07  JULIAN DATE 2750.5000
LAT(DEG) -.22177804 02  LONG(DEG) .21843096 03   V.APO(FPS) .32613809 02  V.PERI(FPS) .39499148 03
ALT(NM)    .28549418 09   APO(NM)    .33223129 09   PERI(NM)    .27428642 08  PERIOD(MIN) .10081621 10
X  .20152534 01  Y -.25828449 01 Z  -.13265000 01    XD   .30292305-06    YD  -.22360275-07 ZD -.35568006-08
R  .35343934 01  A -.52037021 02 D  -.22043593 02     V   .30376802-06 BETA   .51186737 02 AZ  .71970928 02
A  .22262953 01  E  .84745835 00 I   .34987070 02 NODE  -.91391157 01     W  -.19191883 03  M  .10714773 01
R  .66939268-03  V  .23866665-03 G   .45708134-01     S  -.89982412 02  SVE   .11915626 02  F  .15627171 03
ELK  .12614690 03 MLK  .14944239 03 SLK  .13771523 03  RM  .73974200 05 RS  .65641325 05          ELLIPSE
ETA -.53609632-01 ZTA -.94491243 00 RHO  .48383218 05  XP  .67088368 05          VEHICLE IS NOT ECLIPSED
XMV  .63181681 05 YMV -.32884983 05 ZMV -.19970867 05  XM -.15914194 05 YM -.27695284 05  ZM -.11142004 05
XSV  .47686349 05 YSV -.39416270 05 ZSV -.21935209 05  XS -.41886230 03 YS -.21163997 05  ZS -.91776623 04

28 DECEMBER      HR     MIN  - SEC TIME-START  .21312000 07  JULIAN DATE 2760.5000
LAT(DEG) -.21135633 02  LONG(DEG) .21193549 03   V.APO(FPS) .32602766 02  V.PERI(FPS) .39578819 03
ALT(NM)    .29808905 09   APO(NM)    .33173429 09   PERI(NM)    .27323213 08  PERIOD(MIN) .10056302 10
X  .22749949 01  Y -.25870455 01 Z  -.13228823 01    XD   .29730271-06    YD   .12541577-07 ZD  .11884583-07
R  .36903148 01  A -.48672264 02 D  -.21006514 02     V   .29780436-06 BETA   .55137438 02 AZ  .71361003 02
A  .22225663 01  E  .84778966 00 I   .35010717 02 NODE  -.91679280 01     W  -.19198148 03  M  .11262242 01
R  .69892326-03  V  .25098205-03 G   .38859998-01     S  -.89982170 02  SVE   .95868645 01  F  .15732885 03
ELK  .12943153 03 MLK  .15171564 03 SLK  .13868612 03  RM  .71732242 05 RS  .67342890 05          ELLIPSE
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ETA -.49988507-01 ZTA -.10652265 01 RHO  .41736931 05  XP  .75632969 05            VEHICLE IS NOT ECLIPSED
XMV  .62740393 05 YMV -.29622228 05 ZMV -.18212122 05  XM -.93807060 04 YM -.31056562 05  ZM -.12815897 05
XSV  .49692680 05 YSV -.39787888 05 ZSV -.21968760 05  XS  .36670073 04 YS -.20890902 05  ZS -.90592593 04

 7 JANUARY      HR    MIN  - SEC TIME-START  .21456000 07  JULIAN DATE 2770.5000
LAT(DEG) -.20073325 02  LONG(DEG) .20536742 03   V.APO(FPS) .32545711 02  V.PERI(FPS) .39602121 03
ALT(NM)   .30921537 09  APO(NM)   .33217941 09   PERI(NM)    .27295921 08  PERIOD(MIN) .10073860 10
X  .25272343 01  Y -.25614815 01 Z   -.13061057 01    XD    .28558412-06   YD    .46373296-07 ZD  .26832317-07
R  .38280560 01  A -.45385596 02 D   -.19949571 02     V    .29056624-06 BETA    .59298267 02 AZ  .70744143 02
A  .22251526 01  E  .84811842 00 I    .35014288 02 NODE  -.91724075 01      W  -.19195538 03  M  .11750757 01
R  .72501061-03  V  .26215196-03 G    .32422766-01     S  -.89981991 02   SVE    .72526346 01  F  .15822850 03
ELK  .13266975 03 MLK  .15319446 03 SLK  .13960819 03  RM  .69007879 05 RS  .68979349 05          ELLIPSE
ETA -.46823028-01 ZTA -.11863637 01 RHO  .33509582 05  XP  .83141898 05            VEHICLE IS NOT ECLIPSED
XMV  .61221482 05 YMV -.27101760 05 ZMV -.16718618 05  XM -.19455542 04 YM -.32977431 05  ZM -.13915908 05
XSV  .51635896 05 YSV -.40111791 05 ZSV -.21975647 05  XS  .76400317 04 YS -.19967400 05  ZS -.86588796 04

17 JANUARY      HR    MIN  - SEC TIME-START  .21600000 07  JULIAN DATE 2780.5000
LAT(DEG) -.18995416 02  LONG(DEG) .19871278 03   V.APO(FPS) .32637799 02  V.PERI(FPS) .39487898 03
ALT(NM)   .31876391 09  APO(NM)   .33205581 09   PERI(NM)    .27442138 08  PERIOD(MIN) .10074811 10
X  .27668064 01  Y -.25075111 01 Z   -.12767832 01    XD    .26804493-06   YD    .78133433-07 ZD  .40855446-07
R  .39462647 01  A -.42185497 02 D   -.18877278 02     V    .28217386-06 BETA    .63690234 02 AZ  .70137265 02
A  .22252927 01  E  .84731454 00 I    .34985035 02 NODE  -.91387333 01      W  -.19193033 03  M  .12280623 01
R  .74739862-03  V  .27203934-03 G    .26339643-01     S  -.89981898 02   SVE    .49368350 01  F  .15905757 03
ELK  .13585090 03 MLK  .15375035 03 SLK  .14048990 03  RM  .66071435 05 RS  .70553957 05          ELLIPSE
ETA -.44042317-01 ZTA -.13081755 01 RHO  .23933008 05  XP  .89298823 05            VEHICLE IS NOT ECLIPSED
XMV  .58903552 05 YMV -.25539508 05 ZMV -.15605760 05  XM  .59915059 04 YM -.33273814 05  ZM -.14341011 05
XSV  .53521379 05 YSV -.40388343 05 ZSV -.21956881 05  XS  .11373679 05 YS -.18424978 05  ZS -.79898909 04

27 JANUARY      HR    MIN  - SEC TIME-START  .21744000 07  JULIAN DATE 2790.5000
LAT(DEG) -.17907876 02  LONG(DEG) .19196273 03   V.APO(FPS) .32572923 02  V.PERI(FPS) .39610799 03
ALT(NM)   .32664706 09  APO(NM)   .33181364 09   PERI(NM)    .27282681 08  PERIOD(MIN) .10057933 10
X  .29888786 01  Y -.24273345 01 Z   -.12358904 01    XD    .24517590-06   YD    .10688328-06 ZD  .53549879-07
R  .40438562 01  A -.39080815 02 D   -.17795573 02     V    .27276885-06 BETA    .68337283 02 AZ  .69552725 02
A  .22228066 01  E  .84803185 00 I    .35019740 02 NODE  -.91771347 01      W  -.19198494 03  M  .12814358 01
R  .76588185-03  V  .28052274-03 G    .20564239-01     S  -.89981911 02   SVE    .26732797 01  F  .15998732 03
ELK  .13896321 03 MLK  .15326517 03 SLK  .14133358 03  RM  .63252410 05 RS  .72065333 05          ELLIPSE
ETA -.41588247-01 ZTA -.14308285 01 RHO  .13358761 05  XP  .93839303 05            VEHICLE IS NOT ECLIPSED
XMV  .56111106 05 YMV -.25074062 05 ZMV -.14956690 05  XM  .13992623 05 YM -.31858730 05  ZM -.14030947 05
XSV  .55346543 05 YSV -.40619824 05 ZSV -.21913519 05  XS  .14757186 05 YS -.16312968 05  ZS -.70741172 04

 6 FEBRUARY     HR    MIN  - SEC TIME-START  .21888000 07  JULIAN DATE 2800.5000
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LAT(DEG) -.16817868 02  LONG(DEG) .18510243 03   V.APO(FPS) .32564640 02  V.PERI(FPS) .39564980 03
ALT(NM)    .33280103 09  APO(NM)    .33225959 09   PERI(NM)    .27344039 08  PERIOD(MIN) .10079254 10
X  .31891265 01  Y -.23239222 01 Z  -.11847343 01   XD   .21764993-06   YD   .13179562-06 ZD  .64559593-07
R  .41200409 01  A -.36080889 02 D  -.16711574 02    V   .26250623-06 BETA   .73269379 02 AZ  .68999217 02
A  .22259467 01  E  .84790499 00 I   .35002898 02 NODE  -.91592988 01    W  -.19193595 03  M  .13298530 01
R  .78031078-03  V  .28750061-03 G   .15058539-01    S  -.89982045 02  SVE   .76985904 00  F  .16073220 03
ELK  .14199372 03 MLK  .15168418 03 SLK  .14214206 03  RM  .60941018 05 RS  .73519989 05          ELLIPSE
ETA -.39412444-01 ZTA -.15543737 01 RHO  .36742726 04  XP  .96546918 05           VEHICLE IS NOT ECLIPSED
XMV  .53203850 05 YMV -.25759619 05 ZMV -.14818909 05  XM  .21596667 05 YM -.28747651 05  ZM -.12968868 05
XSV  .57115672 05 YSV -.40811998 05 ZSV -.21848793 05  XS  .17684845 05 YS -.13695272 05  ZS -.59389844 04

16 FEBRUARY      HR    MIN  - SEC TIME-START  .22032000 07  JULIAN DATE 2810.5000
LAT(DEG) -.15733562 02  LONG(DEG) .17813290 03   V.APO(FPS) .32639701 02  V.PERI(FPS) .39503693 03
ALT(NM)    .33718595 09  APO(NM)    .33191236 09   PERI(NM)    .27420910 08  PERIOD(MIN) .10067889 10
X  .33638739 01  Y -.22008953 01 Z  -.11249021 01   XD   .18629356-06   YD   .15218773-06 ZD  .73590423-07
R  .41743253 01  A -.33195680 02 D  -.15633396 02    V   .25155903-06 BETA   .78523237 02 AZ  .68482356 02
A  .22242732 01  E  .84736271 00 I   .34990428 02 NODE  -.91460704 01    W  -.19194974 03  M  .13847547 01
R  .79059191-03  V  .29289384-03 G   .97903198-02    S  -.89982310 02  SVE   .20222149 01  F  .16151465 03
ELK  .14492825 03 MLK  .14910590 03 SLK  .14292157 03  RM  .59536110 05 RS  .74918160 05          ELLIPSE
ETA -.37474295-01 ZTA  .46044288 01 RHO  .10708484 05  XP  .97269850 05           VEHICLE IS NOT ECLIPSED
XMV  .50541687 05 YMV -.27553003 05 ZMV -.15195998 05  XM  .28357504 05 YM -.24068688 05  ZM -.11188424 05
XSV  .58831497 05 YSV -.40963189 05 ZSV -.21762419 05  XS  .20067694 05 YS -.10658502 05  ZS -.46220029 04

26 FEBRUARY      HR    MIN  - SEC TIME-START  .22176000 07  JULIAN DATE 2820.5000
LAT(DEG) -.14663991 02  LONG(DEG) .17103783 03   V.APO(FPS) .32548022 02  V.PERI(FPS) .39630678 03
ALT(NM)    .33978720 09  APO(NM)    .33193285 09   PERI(NM)    .27257937 08  PERIOD(MIN) .10061902 10
X  .35102132 01  Y -.20623972 01 Z  -.10582060 01   XD   .15205595-06   YD   .16753487-06 ZD  .80416816-07
R  .42065281 01  A -.30436018 02 D  -.14570009 02    V   .24011624-06 BETA   .84139825 02 AZ  .68004632 02
A  .22233913 01  E  .84820960 00 I   .35023973 02 NODE  -.91800049 01    W  -.19197901 03  M  .14361414 01
R  .79669092-03  V  .29664910-03 G   .47349612-02    S  -.89982720 02  SVE   .40889038 01  F  .16232206 03
ELK  .14775127 03 MLK  .14584154 03 SLK  .14367190 03  RM  .59376504 05 RS  .76259810 05          ELLIPSE
ETA -.35739156-01 ZTA  .44789225 01 RHO  .22634709 05  XP  .95925518 05           VEHICLE IS NOT ECLIPSED
XMV  .48455060 05 YMV -.30330926 05 ZMV -.16053389 05  XM  .33876500 05 YM -.18042311 05  ZM -.87666840 04
XSV  .60491464 05 YSV -.41077398 05 ZSV -.21656152 05  XS  .21840096 05 YS -.72958389 04  ZS -.31639214 04

 7 MARCH         HR    MIN  - SEC TIME-START  .22320000 07  JULIAN DATE 2830.5000
LAT(DEG) -.13618981 02  LONG(DEG) .16380514 03   V.APO(FPS) .32599009 02  V.PERI(FPS) .39518985 03
ALT(NM)    .34061619 09  APO(NM)    .33223949 09   PERI(NM)    .27403106 08  PERIOD(MIN) .10080892 10
X  .36260895 01  Y -.19129503 01 Z  -.98662063 00   XD   .11595628-06   YD   .17748843-06 ZD  .84889216-07
R  .42167907 01  A -.27813971 02 D  -.13531168 02    V   .22837290-06 BETA   .90167313 02 AZ  .67565665 02
A  .22261879 01  E  .84759299 00 I   .34989565 02 NODE  -.91464684 01    W  -.19192536 03  M  .14853485 01
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R  .79863460-03  V  .29874134-03 G  -.12800478-03    S  -.89983284 02  SVE   .61055410 01  F  .16296554 03
ELK  .15044566 03 MLK  .14240296 03 SLK  .14439650 03  RM  .60661433 05 RS  .77550741 05          ELLIPSE
ETA -.34176881-01 ZTA  .43521203 01 RHO  .34577903 05  XP  .92500747 05          VEHICLE IS NOT ECLIPSED
XMV  .47234467 05 YMV -.33893183 05 ZMV -.17319550 05  XM  .37814956 05 YM -.10974798 05  ZM -.58214993 04
XSV  .62100975 05 YSV -.41157706 05 ZSV -.21532059 05  XS  .22948448 05 YS -.37102749 04  ZS -.16089895 04

17 MARCH       HR    MIN  - SEC TIME-START  .22464000 07  JULIAN DATE 2840.5000
LAT(DEG) -.12609108 02  LONG(DEG) .15641568 03   V.APO(FPS) .32620245 02  V.PERI(FPS) .39540047 03
ALT(NM)    .33971093 09  APO(NM)    .33184334 09   PERI(NM)    .27373669 08  PERIOD(MIN) .10063004 10
X  .37103502 01  Y -.17572988 01 Z  -.91221594 00   XD   .79045702-07   YD   .18188592-06 ZD  .86938341-07
R  .42055838 01  A -.25343204 02 D  -.12527366 02   V    .21653865-06 BETA  .96651896 02 AZ  .67162034 02
A  .22235536 01  E  .84757633 00 I   .35002898 02 NODE  -.91589076 01    W  -.19196641 03  M  .15410873 01
R  .79651208-03  V  .29917485-03 G  -.48113760-02   S  -.89984012 02  SVE   .80152200 01  F  .16371959 03
ELK  .15299254 03 MLK  .13934898 03 SLK  .14509931 03  RM  .63378272 05 RS  .78788895 05          ELLIPSE
ETA -.32760798-01 ZTA  .42239115 01 RHO  .45972271 05  XP  .87058372 05          VEHICLE IS NOT ECLIPSED
XMV  .47096503 05 YMV -.37973183 05 ZMV -.18888150 05  XM  .39929242 05 YM -.32440137 04  ZM -.25077471 04
XSV  .63659830 05 YSV -.41202092 05 ZSV -.21389336 05  XS  .23365915 05 YS -.15104492 02  ZS -.65607910 01

27 MARCH       HR    MIN  - SEC TIME-START  .22608000 07  JULIAN DATE 2850.5000
LAT(DEG) -.11645698 02  LONG(DEG) .14886472 03   V.APO(FPS) .32535803 02  V.PERI(FPS) .39632413 03
ALT(NM)    .33713583 09  APO(NM)    .33205354 09   PERI(NM)    .27256417 08  PERIOD(MIN) .10066910 10
X  .37627513 01  Y -.16002495 01 Z  -.83708778 00   XD   .42378137-07   YD   .18073956-06 ZD  .86570925-07
R  .41737047 01  A -.23039422 02 D  -.11569842 02   V    .20483462-06 BETA  .10368344 03 AZ  .66786237 02
A  .22241290 01  E  .84826840 00 I   .35022281 02 NODE  -.91769708 01    W  -.19195596 03  M  .15905306 01
R  .79047438-03  V  .29798830-03 G  -.93170582-02   S  -.89984916 02  SVE   .97920656 01  F  .16441383 03
ELK  .15537111 03 MLK  .13709631 03 SLK  .14577920 03  RM  .67327262 05 RS  .79976389 05          ELLIPSE
ETA -.31466662-01 ZTA  .40938230 01 RHO  .56448766 05  XP  .79715542 05          VEHICLE IS NOT ECLIPSED
XMV  .48172859 05 YMV -.42269051 05 ZMV -.20631606 05  XM  .40081945 05 YM  .47354219 04  ZM  .99782959 03
XSV  .65167129 05 YSV -.41215754 05 ZSV -.21230395 05  XS  .23087676 05 YS  .36821255 04  ZS  .15966184 04

6 APRIL        HR    MIN  - SEC TIME-START  .22752000 07  JULIAN DATE 2860.5000
LAT(DEG) -.10740882 02  LONG(DEG) .14112852 03   V.APO(FPS) .32632629 02  V.PERI(FPS) .39483775 03
ALT(NM)    .33298281 09  APO(NM)    .33214447 09   PERI(NM)    .27447983 08  PERIOD(MIN) .10078784 10
X  .37839429 01  Y -.14465277 01 Z  -.76329550 00   XD   .69629363-08   YD   .17422515-06 ZD  .83864132-07
R  .41222913 01  A -.20920881 02 D  -.10670631 02   V    .19348405-06 BETA  .11129683 03 AZ  .66425167 02
A  .22258776 01  E  .84732215 00 I   .34981334 02 NODE  -.91401879 01    W  -.19192733 03  M  .16416803 01
R  .78073699-03  V  .29524725-03 G  -.13637238-01   S  -.89986007 02  SVE   .11406594 02  F  .16500613 03
ELK  .15755851 03 MLK  .13584733 03 SLK  .14644027 03  RM  .72186189 05 RS  .81117309 05          ELLIPSE
ETA -.30271753-01 ZTA  .39614911 01 RHO  .65674465 05  XP  .70653775 05          VEHICLE IS NOT ECLIPSED
XMV  .50506685 05 YMV -.46453402 05 ZMV -.22405405 05  XM  .38245167 05 YM  .12525298 05  ZM  .45024163 04
XSV  .66628156 05 YSV -.41198943 05 ZSV -.21055966 05  XS  .22123695 05 YS  .72708394 04  ZS  .31529763 04
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16 APRIL         HR    MIN  - SEC TIME-START  .22896000 07  JULIAN DATE 2870.5000
LAT(DEG) -.99077009 01  LONG(DEG) .13318569 03   V.APO(FPS) .32588087 02  V.PERI(FPS) .39584556 03
ALT(NM)     .32737162 09  APO(NM)      .33184988 09   PERI(NM)     .27316397 08  PERIOD(MIN) .10060872 10
X  .37754145 01   Y -.13006415 01 Z   -.69280374 00    XD  -.26262650-07    YD    .16257090-06 ZD  .78961134-07
R  .40528262 01   A -.19008981 02 D   -.98426725 01     V    .18271948-06 BETA    .11956926 03 AZ  .66056223 02
A  .22232396 01   E   .84787371 00 I    .35016128 02 NODE  -.91704403 01     W   -.19197608 03  M  .16967799 01
R  .76758071-03   V   .29105297-03 G   -.17750180-01     S  -.89987302 02  SVE    .12830083 02  F  .16572342 03
ELK  .15952974 03 MLK   .13560792 03 SLK   .14708402 03  RM   .77580147 05 RS   .82208420 05          ELLIPSE
ETA -.29154041-01  ZTA   .38265673 01 RHO   .73356702 05   XP   .60113503 05             VEHICLE IS NOT ECLIPSED
XMV  .54034131 05 YMV -.50201148 05 ZMV -.24059027 05   XM   .34517688 05 YM   .19694784 05   ZM  .78094122 04
XSV  .68040157 05 YSV -.41150844 05 ZSV -.20865509 05   XS   .20511662 05 YS   .10644480 05   ZS  .46158939 04

26 APRIL         HR    MIN  - SEC TIME-START  .23040000 07  JULIAN DATE 2880.5000
LAT(DEG) -.91601138 01  LONG(DEG) .12500584 03   V.APO(FPS) .32544506 02  V.PERI(FPS) .39608375 03
ALT(NM)     .32045179 09  APO(NM)      .33214417 09   PERI(NM)     .27287704 08  PERIOD(MIN) .10072034 10
X  .37394365 01   Y -.11667527 01 Z   -.62742599 00    XD  -.56446403-07    YD    .14653901-06 ZD  .72063397-07
R  .39671602 01   A -.17328598 02 D   -.90998182 01     V    .17278023-06 BETA    .12856050 03 AZ  .65637867 02
A  .22248836 01   E   .84814577 00 I    .35013074 02 NODE  -.91680452 01     W   -.19194929 03  M  .17449210 01
R  .75135610-03   V   .28555240-03 G   -.21611998-01     S  -.89988815 02  SVE    .14033079 02  F  .16632036 03
ELK  .16125809 03 MLK   .13626845 03 SLK   .14770972 03  RM   .83151452 05 RS   .83253866 05          ELLIPSE
ETA -.28091213-01  ZTA   .36883275 01 RHO   .79270635 05   XP   .48357269 05             VEHICLE IS NOT ECLIPSED
XMV  .58599518 05 YMV -.53221029 05 ZMV -.25451577 05   XM   .29108442 05 YM   .25855008 05   ZM  .10735388 05
XSV  .69404744 05 YSV -.41076577 05 ZSV -.20661622 05   XS   .18303216 05 YS   .13710555 05   ZS  .59454327 04

 6 MAY           HR    MIN  - SEC TIME-START  .23184000 07  JULIAN DATE 2890.5000
LAT(DEG) -.85130929 01  LONG(DEG) .11657660 03   V.APO(FPS) .32648830 02  V.PERI(FPS) .39476051 03
ALT(NM)     .31240422 09  APO(NM)      .33202706 09   PERI(NM)     .27457276 08  PERIOD(MIN) .10074239 10
X  .36789651 01   Y -.10485780 01 Z   -.56878208 00    XD  -.82849372-07    YD    .12639643-06 ZD  .63417278-07
R  .38675332 01   A -.15908601 02 D   -.84569265 01     V    .16389578-06 BETA    .13831817 03 AZ  .65084738 02
A  .22252083 01   E   .84722453 00 I    .34982441 02 NODE  -.91425855 01     W   -.19194032 03  M  .17985705 01
R  .73248735-03   V   .27887292-03 G   -.25149778-01     S  -.89990564 02  SVE    .14977363 02  F  .16690242 03
ELK  .16271539 03 MLK   .13767751 03 SLK   .14832160 03  RM   .88575200 05 RS   .84255214 05          ELLIPSE
ETA -.27059777-01  ZTA   .35461575 01 RHO   .83228048 05   XP   .35693051 05             VEHICLE IS NOT ECLIPSED
XMV  .63963113 05 YMV -.55265959 05 ZMV -.26456760 05   XM   .22326500 05 YM   .30671709 05   ZM  .13116056 05
XSV  .70725629 05 YSV -.40974107 05 ZSV -.20443806 05   XS   .15563984 05 YS   .16379857 05   ZS  .71031017 04

16 MAY           HR    MIN  - SEC TIME-START  .23328000 07  JULIAN DATE 2900.5000
LAT(DEG) -.79825903 01  LONG(DEG) .10784293 03   V.APO(FPS) .32555153 02  V.PERI(FPS) .39624024 03
ALT(NM)     .30344367 09  APO(NM)      .33190612 09   PERI(NM)     .27266292 08  PERIOD(MIN) .10061130 10
X  .35975404 01   Y -.94930485 00 Z   -.51826192 00    XD  -.10485839-06    YD    .10289996-06 ZD  .53308302-07
R  .37566038 01   A -.14782040 02 D   -.79298307 01     V    .15628646-06 BETA    .14886668 03 AZ  .64184102 02
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A    .22232776 01  E  .84815530 00 I    .35025902 02 NODE  -.91774844 01    W  -.19197678 03  M  .18518172 01
R    .71147799-03  V  .27125553-03 G   -.28257994-01    S  -.89992565 02  SVE   .15625644 02  F  .16756502 03
ELK  .16387252 03 MLK  .13967184 03 SLK  .14891916 03  RM  .93570475 05 RS   .85209741 05        ELLIPSE
ETA -.26034140-01 ZTA  .33994220 01 RHO  .85094658 05  XP  .22459033 05          VEHICLE IS NOT ECLIPSED
XMV  .69808921 05 YMV -.56163926 05 ZMV -.26977060 05  XM  .14570886 05 YM   .33898114 05  ZM  .14821299 05
XSV  .71999100 05 YSV -.40844711 05 ZSV -.20212357 05  XS  .12380707 05 YS   .18578898 05  ZS  .80565957 04
26 MAY          HR     MIN  - SEC TIME-START  .23472000 07  JULIAN DATE 2910.5000
LAT(DEG) -.75852764 01  LONG(DEG) .98784417 02  V.APO(FPS) .32573513 02  V.PERI(FPS) .39563086 03
ALT(NM)   .29382192 09  APO(NM)   .33217690 09  PERI(NM)   .27345992 08  PERIOD(MIN) .10075860 10
X    .34991780 01  Y -.87152312 00 Z   -.47699552 00   XD  -.12198348-06    YD   .76778731-07 ZD  .42053335-07
R    .36374887 01  A -.13985817 02 D   -.75350802 01    V   .15014469-06 BETA  .16018574 03 AZ  .62202136 02
A    .22254470 01  E  .84785997 00 I    .34997688 02 NODE  -.91556306 01    W  -.19193652 03  M  .18997906 01
R    .68891831-03  V  .26292337-03 G   -.30783143-01    S  -.89994826 02  SVE   .15936206 02  F  .16809044 03
ELK  .16469960 03 MLK  .14210104 03 SLK  .14950273 03  RM  .97912492 05 RS   .86122586 05        ELLIPSE
ETA -.24985573-01 ZTA  .32471285 01 RHO  .84799587 05  XP  .89844673 04          VEHICLE IS NOT ECLIPSED
XMV  .75783186 05 YMV -.55832644 05 ZMV -.26953307 05  XM  .62895449 04 YM   .35391191 05  ZM  .15765444 05
XSV  .73228861 05 YSV -.40692183 05 ZSV -.19969475 05  XS  .88438701 04 YS   .20250730 05  ZS  .87816116 04
 5 JUNE         HR     MIN  - SEC TIME-START  .23616000 07  JULIAN DATE 2920.5000
LAT(DEG) -.73378695 01  LONG(DEG) .89350594 02  V.APO(FPS) .32639311 02  V.PERI(FPS) .39500414 03
ALT(NM)   .28383134 09  APO(NM)   .33194208 09  PERI(NM)   .27425315 08  PERIOD(MIN) .10069324 10
X    .33882622 01  Y -.81716672 00 Z   -.44582815 00   XD  -.13387083-06    YD   .48804520-07 ZD  .29987318-07
R    .35138077 01  A -.13559413 02 D   -.72892742 01    V   .14561085-06 BETA  .17213867 03 AZ  .53733284 02
A    .22244845 01  E  .84735269 00 I    .34993052 02 NODE  -.91518907 01    W  -.19195674 03  M  .19554136 01
R    .66549389-03  V  .25415469-03 G   -.32518723-01    S  -.89997343 02  SVE   .15861881 02  F  .16868079 03
ELK  .16516558 03 MLK  .14483237 03 SLK  .15007593 03  RM  .10141812 06 RS   .86992640 05        ELLIPSE
ETA -.23881500-01 ZTA  .30884500 01 RHO  .82318951 05  XP -.43764917 04          VEHICLE IS NOT ECLIPSED
XMV  .81512871 05 YMV -.54278690 05 ZMV -.26364958 05  XM -.20416553 04 YM   .35112159 05  ZM  .15908121 05
XSV  .74416077 05 YSV -.40513344 05 ZSV -.19713852 05  XS  .50551387 04 YS   .21346812 05  ZS  .92570148 04
15 JUNE         HR     MIN  - SEC TIME-START  .23760000 07  JULIAN DATE 2930.5000
LAT(DEG) -.72560270 01  LONG(DEG) .79518126 02  V.APO(FPS) .32532092 02  V.PERI(FPS) .39646641 03
ALT(NM)   .27380724 09  APO(NM)   .33198416 09  PERI(NM)   .27237833 08  PERIOD(MIN) .10063213 10
X    .32694208 01  Y -.78749207 00 Z   -.42531088 00   XD  -.14030531-06    YD   .19779077-07 ZD  .17458579-07
R    .33897117 01  A -.13542635 02 D   -.72079622 01    V   .14276412-06 BETA  .17452102 03 AZ  .26842221 03
A    .22235844 01  E  .84833471 00 I    .35029320 02 NODE  -.91788182 01    W  -.19196902 03  M  .20063098 01
R    .64199085-03  V  .24524318-03 G   -.33201587-01    S   .26999991 03  SVE   .15361461 02  F  .16927618 03
ELK  .16523721 03 MLK  .14774271 03 SLK  .15063699 03  RM  .10395352 06 RS   .87819028 05        ELLIPSE
ETA -.22685238-01 ZTA  .29225951 01 RHO  .77686648 05  XP -.17268156 05          VEHICLE IS NOT ECLIPSED
XMV  .86634850 05 YMV -.51611614 05 ZMV -.25238436 05  XM -.99510410 04 YM   .33141097 05  ZM  .15262829 05
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XSV  .75557776 05 YSV -.40311599 05 ZSV -.19446833 05  XS  .11260322 04 YS  .21841083 05  ZS  .94712256 04

25 JUNE          HR    MIN  - SEC TIME-START  .23904000 07  JULIAN DATE 2940.5000
LAT(DEG) -.73522708 01  LONG(DEG) .69229400 02   V.APO(FPS) .32612650 02  V.PERI(FPS) .39511612 03
ALT(NM)   .26412817 09  APO(NM)    .33214717 09   PERI(NM)    .27412071 08  PERIOD(MIN) .10077388 10
X  .31474102 01  Y -.78305334 00 Z   -.41568972 00   XD  -.14120341-06   YD  -.94768562-08 ZD  .48234007-08
R  .32698871 01  A -.13971132 02 D   -.73035822 01    V   .14160324-06 BETA   .16146497 03 AZ  .25408318 03
A  .22256720 01  E  .84750780 00 I    .34984479 02 NODE  -.91466112 01    W  -.19193199 03  M  .20555283 01
R  .61929679-03  V  .23654731-03 G   -.32518810-01    S   .26999701 03  SVE   .14395467 02  F  .16976344 03
ELK  .16487957 03 MLK  .15072276 03 SLK  .15118765 03  RM  .10543793 06 RS  .88606528 05          ELLIPSE
ETA -.21356767-01 ZTA  .27485980 01 RHO  .70986468 05  XP -.29364050 05           VEHICLE IS NOT ECLIPSED
XMV  .90838098 05 YMV -.48027315 05 ZMV -.23642631 05  XM -.17016030 05 YM  .29660909 05  ZM  .13892687 05
XSV  .76658780 05 YSV -.40088335 05 ZSV -.19169604 05  XS -.28367129 04 YS  .21721929 05  ZS  .94196600 04

 5 JULY          HR    MIN  - SEC TIME-START  .24048000 07  JULIAN DATE 2950.5000
LAT(DEG) -.76329365 01  LONG(DEG) .58476264 02   V.APO(FPS) .32608856 02  V.PERI(FPS) .39547270 03
ALT(NM)   .25521212 09  APO(NM)    .33191207 09   PERI(NM)    .27364780 08  PERIOD(MIN) .10065518 10
X  .30270036 01  Y -.80369994 00 Z   -.41690494 00   XD  -.13661258-06   YD  -.38150946-07 ZD -.75657520-08
R  .31595085 01  A -.14869531 02 D   -.75824323 01    V   .14204130-06 BETA   .14778933 03 AZ  .25181377 03
A  .22239240 01  E  .84765120 00 I    .35009175 02 NODE  -.91637356 01    W  -.19196873 03  M  .21116999 01
R  .59839175-03  V  .22844633-03 G   -.30141457-01    S   .26999407 03  SVE   .12936961 02  F  .17035667 03
ELK  .16406124 03 MLK  .15366989 03 SLK  .15173012 03  RM  .10583163 06 RS  .89352031 05          ELLIPSE
ETA -.19855462-01 ZTA  .25659487 01 RHO  .62354954 05  XP -.40333416 05           VEHICLE IS NOT ECLIPSED
XMV  .93876031 05 YMV -.43789968 05 ZMV -.21680950 05  XM -.22878086 05 YM  .24939299 05  ZM  .11902503 05
XSV  .77717464 05 YSV -.39840887 05 ZSV -.18880811 05  XS -.67195186 04 YS  .20990217 05  ZS  .91023640 04

15 JULY          HR    MIN  - SEC TIME-START  .24192000 07  JULIAN DATE 2960.5000
LAT(DEG) -.80941791 01  LONG(DEG) .47243585 02   V.APO(FPS) .32526913 02  V.PERI(FPS) .39644846 03
ALT(NM)   .24750411 09  APO(NM)    .33205492 09   PERI(NM)    .27240535 08  PERIOD(MIN) .10066300 10
X  .29128736 01  Y -.84858298 00 Z   -.42859361 00   XD  -.12671541-06   YD  -.65449019-07 ZD -.19363928-07
R  .30640852 01  A -.16241981 02 D   -.80407015 01    V   .14392821-06 BETA   .13380484 03 AZ  .25110946 03
A  .22240392 01  E  .84835067 00 I    .35023375 02 NODE  -.91735674 01    W  -.19195709 03  M  .21605552 01
R  .58031916-03  V  .22132134-03 G   -.25789661-01    S   .26999129 03  SVE   .10986422 02  F  .17088535 03
ELK  .16276622 03 MLK  .15643104 03 SLK  .15226238 03  RM  .10514889 06 RS  .90057100 05          ELLIPSE
ETA -.18145406-01 ZTA  .23745451 01 RHO  .51981075 05  XP -.49868873 05           VEHICLE IS NOT ECLIPSED
XMV  .95594026 05 YMV -.39220789 05 ZMV -.19488474 05  XM -.27272983 05 YM  .19317393 05  ZM  .94358712 04
XSV  .78732978 05 YSV -.39573830 05 ZSV -.18582556 05  XS -.10411936 05 YS  .19670434 05  ZS  .85299530 04

25 JULY          HR    MIN  - SEC TIME-START  .24336000 07  JULIAN DATE 2970.5000
LAT(DEG) -.87178237 01  LONG(DEG) .35575050 02   V.APO(FPS) .32645007 02  V.PERI(FPS) .39474570 03
ALT(NM)   .24145284 09  APO(NM)    .33208043 09   PERI(NM)    .27459503 08  PERIOD(MIN) .10076576 10
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X  .28094798 01  Y -.91617821 00 Z   -.45009959 00     XD   -.11182120-06     YD  -.90602780-07 ZD -.30237837-07
R  .29891719 01  A -.18061273 02 D   -.86603476 01      V    .14706180-06 BETA    .11965113 03 AZ   .25096850 03
A  .22255525 01  E  .84723577 00 I    .34977355 02 NODE  -.91430104 01      W  -.19193882 03  M   .22121359 01
R  .56613104-03  V  .21559954-03 G   -.19339782-01      S    .26998892 03  SVE   .85740840 01  F   .17136692 03
ELK  .16101052 03 MLK  .15905706 03 SLK  .15278726 03  RM  .10345606 06 RS  .90724855 05         ELLIPSE
ETA -.16203620-01 ZTA  .21746508 01 RHO  .40088721 05  XP -.57704184 05            VEHICLE IS NOT ECLIPSED
XMV  .95945777 05 YMV -.34658415 05 ZMV -.17215055 05  XM -.30049822 05 YM  .13169584 05  ZM  .66580322 04
XSV  .79709719 05 YSV -.39286030 05 ZSV -.18274792 05  XS -.13813764 05 YS  .17797198 05  ZS  .77177695 04

 4 AUGUST        HR    MIN  - SEC TIME-START  .24480000 07  JULIAN DATE 2980.5000
LAT(DEG) -.94686118 01  LONG(DEG) .23516782 02   V.APO(FPS) .32570729 02  V.PERI(FPS) .39598785 03
ALT(NM)    .23747490 09  APO(NM)    .33193072 09   PERI(NM)    .27298752 08  PERIOD(MIN) .10063528 10
X  .27209629 01  Y -.10043190 01 Z   -.48048810 00     XD   -.92357719-07     YD  -.11289540-06 ZD -.39876401-07
R  .29399259 01  A -.20259317 02 D   -.94063581 01      V    .15121325-06 BETA    .10549417 03 AZ   .25113684 03
A  .22236308 01  E  .84799871 00 I    .35023444 02 NODE  -.91726713 01      W  -.19197236 03  M   .22671787 01
R  .55680415-03  V  .21161782-03 G   -.10935536-01      S    .26998724 03  SVE   .57770107 01  F   .17194274 03
ELK  .15885698 03 MLK  .16129555 03 SLK  .15330523 03  RM  .10086397 06 RS  .91351371 05         ELLIPSE
ETA -.14029930-01 ZTA  .19675600 01 RHO  .26956773 05  XP -.63592579 05            VEHICLE IS NOT ECLIPSED
XMV  .94982744 05 YMV -.30436666 05 ZMV -.15014282 05  XM -.31162940 05 YM  .68805059 04  ZM  .37445006 04
XSV  .80644028 05 YSV -.38976510 05 ZSV -.17956767 05  XS -.16824224 05 YS  .15420349 05  ZS  .66869855 04

14 AUGUST        HR    MIN  - SEC TIME-START  .24624000 07  JULIAN DATE 2990.5000
LAT(DEG) -.10295041 02  LONG(DEG) .11197600 02   V.APO(FPS) .32544631 02  V.PERI(FPS) .39614205 03
ALT(NM)    .23590958 09  APO(NM)    .33209762 09   PERI(NM)    .27279968 08  PERIOD(MIN) .10069752 10
X  .26510443 01  Y -.11102478 01 Z   -.51856786 00     XD   -.68873554-07     YD  -.13167254-06 ZD -.47995434-07
R  .29205477 01  A -.22723759 02 D   -.10227577 02      V    .15615628-06 BETA    .91446022 02 AZ   .25152011 03
A  .22245476 01  E  .84816588 00 I    .35011130 02 NODE  -.91651026 01      W  -.19194405 03  M   .23149504 01
R  .55313402-03  V  .20972441-03 G   -.10766022-02      S    .26998648 03  SVE   .27212839 01  F   .17241800 03
ELK  .15642026 03 MLK  .16308984 03 SLK  .15381500 03  RM  .97543591 05 RS  .91940429 05         ELLIPSE
ETA -.11654611-01 ZTA  .17553530 01 RHO  .12907529 05  XP -.67333156 05            VEHICLE IS NOT ECLIPSED
XMV  .92861353 05 YMV -.26862932 05 ZMV -.13034730 05  XM -.30681479 05 YM  .82222485 03  ZM  .87179346 03
XSV  .81537739 05 YSV -.38649660 05 ZSV -.17630749 05  XS -.19357865 05 YS  .12608953 05  ZS  .54678126 04

24 AUGUST        HR    MIN  - SEC TIME-START  .24768000 07  JULIAN DATE 3000.5000
LAT(DEG) -.11135127 02  LONG(DEG)-.12438150 01   V.APO(FPS) .32653915 02  V.PERI(FPS) .39470678 03
ALT(NM)    .23697207 09  APO(NM)    .33201315 09   PERI(NM)    .27464140 08  PERIOD(MIN) .10073942 10
X  .26029184 01  Y -.12306687 01 Z   -.56291380 00     XD   -.42031308-07     YD  -.14635168-06 ZD -.54342371-07
R  .29337010 01  A -.25304944 02 D   -.11062424 02      V    .16167417-06 BETA    .77668428 02 AZ   .25207126 03
A  .22251647 01  E  .84718335 00 I    .34983383 02 NODE  -.91480198 01      W  -.19195190 03  M   .23692197 01
R  .55562519-03  V  .21008905-03 G    .94162089-02      S    .26998674 03  SVE   .46373142 00  F   .17291660 03
ELK  .15385749 03 MLK  .16433531 03 SLK  .15431975 03  RM  .93718431 05 RS  .92492682 05         ELLIPSE
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ETA -.91393173-02 ZTA  .15405513 01 RHO  .24927897 04  XP -.68775203 05             VEHICLE IS NOT ECLIPSED
XMV  .89824008 05 YMV -.24182259 05 ZMV -.11402208 05  XM -.28772920 05 YM -.46829038 04  ZM -.18008564 04
XSV  .82393398 05 YSV -.38302539 05 ZSV -.17295652 05  XS -.21342311 05 YS  .94373760 04  ZS  .40925874 04

 3 SEPTEMBER     HR     MIN  - SEC TIME-START  .24912000 07  JULIAN DATE 3010.5000
LAT(DEG) -.11926267 02  LONG(DEG)-.13622576 02   V.APO(FPS) .32538724 02  V.PERI(FPS) .39638723 03
ALT(NM)    .24072108 09  APO(NM)    .33197263 09   PERI(NM)    .27247883 08  PERIOD(MIN) .10063151 10
X  .25791647 01  Y -.13618225 01 Z   -.61189999 00   XD   -.12588447-07   YD   -.15644644-06 ZD -.58705976-07
R  .29801129 01  A -.27834463 02 D   -.11848688 02    V    .16757192-06 BETA   .64307039 02 AZ  .25276465 03
A  .22235753 01  E  .84827813 00 I    .35030417 02 NODE -.91759332 01    W   -.19196831 03  M  .24219736 01
R  .56441531-03  V  .21282240-03 G    .19558578-01    S    .26998795 03  SVE   .35288112 01  F  .17345451 03
ELK  .15134542 03 MLK  .16492310 03 SLK  .15481838 03  RM  .89662190 05 RS  .93004968 05          ELLIPSE
ETA -.65679968-02 ZTA  .13262395 01 RHO  .17244671 05  XP -.67816829 05             VEHICLE IS NOT ECLIPSED
XMV  .86171378 05 YMV -.22571053 05 ZMV -.10215161 05  XM -.25677430 05 YM -.93703047 04  ZM -.41368680 04
XSV  .83206865 05 YSV -.37936504 05 ZSV -.16951789 05  XS -.22712917 05 YS  .59951470 04  ZS  .25997605 04

13 SEPTEMBER     HR     MIN  - SEC TIME-START  .25056000 07  JULIAN DATE 3020.5000
LAT(DEG) -.12615606 02  LONG(DEG)-.25798761 02   V.APO(FPS) .32582055 02  V.PERI(FPS) .39560676 03
ALT(NM)    .24705136 09  APO(NM)    .33210188 09   PERI(NM)    .27348652 08  PERIOD(MIN) .10072818 10
X  .25816694 01  Y -.14995783 01 Z   -.66373898 00   XD    .18605060-07   YD   -.16158175-06 ZD -.60923389-07
R  .30584803 01  A -.30150421 02 D   -.12533825 02    V    .17368497-06 BETA   .51488073 02 AZ  .25360175 03
A  .22249991 01  E  .84781454 00 I    .34994440 02 NODE -.91553346 01    W   -.19193684 03  M  .24699764 01
R  .57925762-03  V  .21783995-03 G    .28444705-01    S    .26998990 03  SVE   .63695534 01  F  .17389869 03
ELK  .14905177 03 MLK  .16475009 03 SLK  .15531091 03  RM  .85708116 05 RS  .93482017 05          ELLIPSE
ETA -.40299400-02 ZTA  .11152625 01 RHO  .31859655 05  XP -.64420494 05             VEHICLE IS NOT ECLIPSED
XMV  .82252705 05 YMV -.22122467 05 ZMV -.95378339 04  XM -.21700010 05 YM -.13049932 05  ZM -.60300710 04
XSV  .83981982 05 YSV -.37554306 05 ZSV -.16600855 05  XS -.23429288 05 YS  .23819062 04  ZS  .10329498 04

23 SEPTEMBER     HR     MIN  - SEC TIME-START  .25200000 07  JULIAN DATE 3030.5000
LAT(DEG) -.13166796 02  LONG(DEG) .32237629 03   V.APO(FPS) .32635777 02  V.PERI(FPS) .39501065 03
ALT(NM)    .25571246 09  APO(NM)    .33197571 09   PERI(NM)    .27424672 08  PERIOD(MIN) .10070710 10
X  .26115507 01  Y -.16395329 01 Z   -.71652520 00   XD    .50621139-07   YD   -.16150423-06 ZD -.60884792-07
R  .31657027 01  A -.32120623 02 D   -.13081688 02    V    .17986960-06 BETA   .39302947 02 AZ  .25464748 03
A  .22246887 01  E  .84737028 00 I    .34996815 02 NODE -.91564819 01    W   -.19196528 03  M  .25261002 01
R  .59956490-03  V  .22496780-03 G    .35447945-01    S    .26999231 03  SVE   .88401592 01  F  .17441724 03
ELK  .14711084 03 MLK  .16374945 03 SLK  .15580007 03  RM  .82222083 05 RS  .93922019 05          ELLIPSE
ETA -.16021425-02 ZTA  .90968904 00 RHO  .45861399 05  XP -.58607282 05             VEHICLE IS NOT ECLIPSED
XMV  .78427624 05 YMV -.22833661 05 ZMV -.93916293 04  XM -.17174068 05 YM -.15621354 05  ZM -.74143690 04
XSV  .84718720 05 YSV -.37152473 05 ZSV -.16241245 05  XS -.23465164 05 YS -.13025420 04  ZS -.56475330 03

 3 OCTOBER       HR     MIN  - SEC TIME-START  .25344000 07  JULIAN DATE 3040.5000
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LAT(DEG) -.13561238 02  LONG(DEG) .31098049 03   V.APO(FPS) .32522802 02  V.PERI(FPS) .39655996 03
ALT(NM)    .26634660 09  APO(NM)    .33201377 09   PERI(NM)    .27226058 08  PERIOD(MIN) .10063963 10
X  .26691007 01  Y -.17771225 01 Z   -.76828334 00   XD   .82485867-07   YD  -.15610149-06 ZD -.58541091-07
R  .32973507 01  A -.33656199 02 D   -.13473770 02   V    .18600713-06 BETA  .27798005 02 AZ  .25614354 03
A  .22236948 01  E  .84840779 00 I    .35029475 02 NODE  -.91743331 01   W  -.19195872 03  M  .25763697 01
R  .62449824-03  V  .23391873-03 G    .40303378-01   S    .26999491 03  SVE  .10852281 02  F  .17490904 03
ELK  .14561077 03 MLK  .16193709 03 SLK  .15628382 03  RM  .79577181 05 RS  .94323881 05       ELLIPSE
ETA  .66232060-03 ZTA  .71108942 00 RHO  .58829853 05  XP -.50475963 05        VEHICLE IS NOT ECLIPSED
XMV  .75040715 05 YMV -.24620212 05 ZMV -.97603317 04  XM -.12437332 05 YM -.17061947 05  ZM -.82596466 04
XSV  .85414165 05 YSV -.36734435 05 ZSV -.15874387 05  XS -.22810782 05 YS -.49477236 04  ZS -.21455908 04

13 OCTOBER      HR    MIN  - SEC TIME-START  .25488000 07  JULIAN DATE 3050.5000
LAT(DEG) -.13794936 02  LONG(DEG) .30007389 03   V.APO(FPS) .32624422 02  V.PERI(FPS) .39504403 03
ALT(NM)    .27853333 09  APO(NM)    .33207415 09   PERI(NM)    .27420942 08  PERIOD(MIN) .10074691 10
X  .27537543 01  Y -.19077539 01 Z   -.81702523 00   XD   .11319419-06   YD  -.14541847-06 ZD -.53911762-07
R  .34482196 01  A -.34713554 02 D   -.13706076 02   V    .19200503-06 BETA  .16990255 02 AZ  .25899693 03
A  .22252749 01  E  .84743124 00 I    .34981351 02 NODE  -.91489985 01   W  -.19193948 03  M  .26259861 01
R  .65307188-03  V  .24435206-03 G    .43057869-01   S    .26999748 03  SVE  .12367838 02  F  .17534880 03
ELK  .14459325 03 MLK  .15947832 03 SLK  .15676357 03  RM  .78108185 05 RS  .94691852 05       ELLIPSE
ETA  .27372518-02 ZTA  .52015966 00 RHO  .70366806 05  XP -.40197482 05        VEHICLE IS NOT ECLIPSED
XMV  .72406934 05 YMV -.27313355 05 ZMV -.10587975 05  XM -.78180117 04 YM -.17432747 05  ZM -.85752371 04
XSV  .86072870 05 YSV -.36300547 05 ZSV -.15500913 05  XS -.21483947 05 YS -.84455547 04  ZS -.36622992 04

23 OCTOBER      HR    MIN  - SEC TIME-START  .25632000 07  JULIAN DATE 3060.5000
LAT(DEG) -.13873537 02  LONG(DEG) .28963967 03   V.APO(FPS) .32599765 02  V.PERI(FPS) .39552294 03
ALT(NM)    .29182869 09  APO(NM)    .33197271 09   PERI(NM)    .27358673 08  PERIOD(MIN) .10067810 10
X  .28640751 01  Y -.20269431 01 Z   -.86080988 00   XD   .14173660-06   YD  -.12966160-06 ZD -.47086333-07
R  .36128130 01  A -.35287538 02 D   -.13784210 02   V    .19778402-06 BETA  .69585360 01 AZ  .26924097 03
A  .22242615 01  E  .84770831 00 I    .35013776 02 NODE  -.91654464 01   W  -.19197179 03  M  .26823020 01
R  .68424489-03  V  .25591020-03 G    .43958846-01   S    .26999992 03  SVE  .13386636 02  F  .17587194 03
ELK  .14406189 03 MLK  .15669430 03 SLK  .15724092 03  RM  .78030099 05 RS  .95022246 05       ELLIPSE
ETA  .46193978-02 ZTA  .33678333 00 RHO  .80107082 05  XP -.28001622 05        VEHICLE IS NOT ECLIPSED
XMV  .70774823 05 YMV -.30672622 05 ZMV -.11781808 05  XM -.35983428 04 YM -.16869045 05  ZM -.84083675 04
XSV  .86692187 05 YSV -.35848230 05 ZSV -.15119403 05  XS -.19515707 05 YS -.11693437 05  ZS -.50707720 04

2 NOVEMBER      HR    MIN  - SEC TIME-START  .25776000 07  JULIAN DATE 3070.5000
LAT(DEG) -.13807720 02  LONG(DEG) .27966637 03   V.APO(FPS) .32527645 02  V.PERI(FPS) .39645601 03
ALT(NM)    .30579384 09  APO(NM)    .33204102 09   PERI(NM)    .27239490 08  PERIOD(MIN) .10065673 10
X  .29977707 01  Y -.21304533 01 Z   -.89780354 00   XD   .16714490-06   YD  -.10920084-06 ZD -.38224909-07
R  .37856983 01  A -.35400616 02 D   -.13718784 02   V    .20328154-06 BETA  .36191781 01 AZ  .37510103 02
A  .22239467 01  E  .84835019 00 I    .35020847 02 NODE  -.91690944 01   W  -.19194688 03  M  .27306015 01
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R    .71698832-03  V   .26818706-03 G   .43344523-01      S  -.89997824 02  SVE   .13930973 02  F  .17632283 03
ELK  .14399371 03 MLK  .15398818 03 SLK  .15771374 03   RM  .79395865 05 RS   .95316558 05          ELLIPSE
ETA  .63216390-02 ZTA  .16071018 00 RHO  .87714002 05   XP -.14208311 05              VEHICLE IS NOT ECLIPSED
XMV  .70317749 05 YMV -.34412696 05 ZMV -.13224372 05   XM -.54560547 01 YM -.15556790 05  ZM -.78334845 04
XSV  .87271648 05 YSV -.35381847 05 ZSV -.14731953 05   XS -.16959355 05 YS -.14587638 05  ZS -.63259037 04

12 NOVEMBER       HR     MIN  - SEC TIME-START  .25920000 07  JULIAN DATE 3080.5000
LAT(DEG) -.13609990 02  LONG(DEG) .27012003 03   V.APO(FPS) .32653786 02  V.PERI(FPS) .39467687 03
ALT(NM)    .32001332 09  APO(NM)    .33203780 09   PERI(NM)    .27468152 08  PERIOD(MIN) .10075147 10
X    .31517397 01  Y -.22144406 01 Z  -.92634265 00    XD    .18852041-06    YD  -.84575807-07 ZD -.27561646-07
R    .39617322 01  A -.35092221 02 D  -.13522231 02     V    .20845300-06 BETA   .12264628 02 AZ  .62218997 02
A    .22253421 01  E   .84717321 00 I    .34977339 02 NODE  -.91481175 01     W  -.19195122 03  M   .27828663 01
R    .75032806-03  V   .28085928-03 G   .41555854-01     S  -.89995789 02  SVE   .14043420 02  F  .17678082 03
ELK  .14434993 03 MLK  .15174195 03 SLK  .15818457 03   RM  .82078221 05 RS   .95577329 05          ELLIPSE
ETA  .78662346-02 ZTA -.86727023-02 RHO  .92913626 05   XP  .80584869 03              VEHICLE IS NOT ECLIPSED
XMV  .71122791 05 YMV -.38210718 05 ZMV -.14775791 05   XM  .28008242 04 YM -.13728678 05  ZM -.69514468 04
XSV  .87815022 05 YSV -.34899415 05 ZSV -.14338010 05   XS -.13891407 05 YS -.17039980 05  ZS -.73892268 04

22 NOVEMBER       HR     MIN  - SEC TIME-START  .26064000 07  JULIAN DATE 3090.5000
LAT(DEG) -.13292925 02  LONG(DEG) .26095267 03   V.APO(FPS) .32560968 02  V.PERI(FPS) .39604845 03
ALT(NM)    .33410490 09  APO(NM)    .33199083 09   PERI(NM)    .27291335 08  PERIOD(MIN) .10065742 10
X    .33221430 01  Y -.22755994 01 Z  -.94499714 00    XD    .20506759-06    YD  -.56482908-07 ZD -.15398432-07
R    .41361825 01  A -.34410338 02 D  -.13207061 02     V    .21326075-06 BETA   .20845373 02 AZ  .65926926 02
A    .22239569 01  E   .84806228 00 I    .35026684 02 NODE  -.91710181 01     W  -.19196967 03  M   .28376580 01
R    .78336791-03  V   .29357936-03 G   .38898034-01     S  -.89993957 02  SVE   .13771230 02  F  .17728690 03
ELK  .14508412 03 MLK  .15021409 03 SLK  .15865343 03   RM  .85797825 05 RS   .95800347 05          ELLIPSE
ETA  .92796079-02 ZTA -.17224303 00 RHO  .95499791 05   XP  .16626696 05              VEHICLE IS NOT ECLIPSED
XMV  .73171207 05 YMV -.41737232 05 ZMV -.16286339 05   XM  .47491914 04 YM -.11636634 05  ZM -.58784365 04
XSV  .88318058 05 YSV -.34400401 05 ZSV -.13936989 05   XS -.10397660 05 YS -.18973465 05  ZS -.82277864 04

 2 DECEMBER       HR     MIN  - SEC TIME-START  .26208000 07  JULIAN DATE 3100.5000
LAT(DEG) -.12868349 02  LONG(DEG) .25209732 03   V.APO(FPS) .32553818 02  V.PERI(FPS) .39607870 03
ALT(NM)    .34772394 09  APO(NM)    .33204587 09   PERI(NM)    .27287780 08  PERIOD(MIN) .10067905 10
X    .35045177 01  Y -.23112819 01 Z  -.95262208 00    XD    .21613984-06    YD  -.25748403-07 ZD -.20933794-08
R    .43047830 01  A -.33405443 02 D  -.12785039 02     V    .21767818-06 BETA   .29075201 02 AZ  .67181231 02
A    .22242756 01  E   .84810384 00 I    .35005645 02 NODE  -.91617039 01     W  -.19193878 03  M   .28851444 01
R    .81529981-03  V   .30604469-03 G   .35618426-01     S  -.89992317 02  SVE   .13162231 02  F  .17771393 03
ELK  .14614780 03 MLK  .14951421 03 SLK  .15911899 03   RM  .90201950 05 RS   .95989161 05          ELLIPSE
ETA  .10589046-01 ZTA -.33058653 00 RHO  .95347976 05   XP  .32772186 05              VEHICLE IS NOT ECLIPSED
XMV  .76352187 05 YMV -.44683533 05 ZMV -.17610144 05   XM  .58457852 04 YM -.95272502 04  ZM -.47334741 04
XSV  .88782844 05 YSV -.33888623 05 ZSV -.13530971 05   XS -.65848711 04 YS -.20322170 05  ZS -.88126470 04
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12 DECEMBER      HR     MIN  - SEC TIME-START  .26352000 07  JULIAN DATE 3110.5000
LAT(DEG) -.12347167 02  LONG(DEG) .24351569 03   V.APO(FPS) .32655657 02  V.PERI(FPS) .39467741 03
ALT(NM)   .36056478 09  APO(NM)    .33201690 09   PERI(NM)   .27467960 08  PERIOD(MIN) .10074261 10
X  .36939182 01  Y -.23196035 01 Z  -.94840351 00   XD   .22126748-06   YD   .66870530-08 ZD  .11945375-07
R  .44637496 01  A -.32126850 02 D  -.12267017 02    V   .22169057-06 BETA   .36981050 02 AZ  .67641064 02
A  .22252116 01  E  .84716532 00 I   .34986045 02 NODE  -.91530225 01    W  -.19196510 03  M  .29400304 01
R  .84540712-03  V  .31794962-03 G   .31913373-01    S  -.89990857 02  SVE   .12267048 02  F  .17819832 03
ELK  .14749378 03 MLK  .14963526 03 SLK  .15958417 03  RM  .94912682 05 RS  .96143844 05        ELLIPSE
ETA  .11820796-01 ZTA -.48438454 00 RHO  .92426401 05  XP  .48750021 05         VEHICLE IS NOT ECLIPSED
XMV  .80462710 05 YMV -.46774213 05 ZMV -.18610278 05  XM  .61776240 04 YM -.76317627 04  ZM -.36343936 04
XSV  .89211053 05 YSV -.33360629 05 ZSV -.13118510 05  XS -.25707187 04 YS -.21045346 05  ZS -.91261619 04

22 DECEMBER      HR     MIN  - SEC TIME-START  .26496000 07  JULIAN DATE 3120.5000
LAT(DEG) -.11739515 02  LONG(DEG) .23517252 03   V.APO(FPS) .32532885 02  V.PERI(FPS) .39642036 03
ALT(NM)   .37236070 09  APO(NM)    .33201109 09   PERI(NM)   .27243872 08  PERIOD(MIN) .10064599 10
X  .38850750 01  Y -.22995296 01 Z  -.93189610 00   XD   .22017777-06   YD   .39803590-07 ZD  .26275782-07
R  .46097803 01  A -.30620784 02 D  -.11663081 02    V   .22528424-06 BETA   .44604361 02 AZ  .67735271 02
A  .22237886 01  E  .84831501 00 I   .35031352 02 NODE  -.91720809 01    W  -.19196058 03  M  .29922982 01
R  .87306445-03  V  .32905910-03 G   .27927778-01    S  -.89989562 02  SVE   .11128949 02  F  .17867289 03
ELK  .14907765 03 MLK  .15049065 03 SLK  .16004764 03  RM  .99571445 05 RS  .96261208 05        ELLIPSE
ETA  .12999242-01 ZTA -.63439434 00 RHO  .86789344 05  XP  .64077247 05         VEHICLE IS NOT ECLIPSED
XMV  .85216058 05 YMV -.47801783 05 ZMV -.19175138 05  XM  .59078340 04 YM -.61333638 04  ZM -.26823545 04
XSV  .89598502 05 YSV -.32813211 05 ZSV -.12700147 05  XS  .15253896 04 YS -.21116936 05  ZS -.91573456 04

1 JANUARY        HR     MIN  - SEC TIME-START  .26640000 07  JULIAN DATE 3130.5000
LAT(DEG) -.11054983 02  LONG(DEG) .22700899 03   V.APO(FPS) .32595609 02  V.PERI(FPS) .39550367 03
ALT(NM)   .38288327 09  APO(NM)    .33203320 09   PERI(NM)   .27361503 08  PERIOD(MIN) .10070472 10
X  .40725774 01  Y -.22509268 01 Z  -.90304505 00   XD   .21281828-06   YD   .72553724-07 ZD  .40443582-07
R  .47400473 01  A -.28929570 02 D  -.10982778 02    V   .22845425-06 BETA   .51987009 02 AZ  .67630272 02
A  .22246535 01  E  .84771939 00 I   .34989220 02 NODE  -.91551250 01    W  -.19193857 03  M  .30403981 01
R  .89773622-03  V  .33914487-03 G   .23767665-01    S  -.89988426 02  SVE   .97890534 01  F  .17909874 03
ELK  .15085849 03 MLK  .15196157 03 SLK  .16050939 03  RM  .10387042 06 RS  .96345683 05        ELLIPSE
ETA  .14146786-01 ZTA -.78100287 00 RHO  .78601408 05  XP  .78259992 05         VEHICLE IS NOT ECLIPSED
XMV  .90276540 05 YMV -.47639717 05 ZMV -.19226741 05  XM  .52451943 04 YM -.51554551 04  ZM -.19540542 04
XSV  .89949046 05 YSV -.32263419 05 ZSV -.12277288 05  XS  .55726885 04 YS -.20531753 05  ZS -.89035071 04

11 JANUARY       HR     MIN  - SEC TIME-START  .26784000 07  JULIAN DATE 3140.5000
LAT(DEG) -.10302786 02  LONG(DEG) .21898707 03   V.APO(FPS) .32630063 02  V.PERI(FPS) .39503561 03
ALT(NM)   .39194116 09  APO(NM)    .33201890 09   PERI(NM)   .27421703 08  PERIOD(MIN) .10072401 10
X  .42510674 01  Y -.21745638 01 Z  -.86218721 00   XD   .19936224-06   YD   .10389356-06 ZD  .53995888-07
R  .48521818 01  A -.27091269 02 D  -.10235274 02    V   .23120279-06 BETA   .59164591 02 AZ  .67407241 02
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A  .22249376 01   E  .84740383 00 I   .35001463 02 NODE  -.91597319 01    W  -.19197427 03  M  .30968021 01
R  .91897382-03   V  .34800039-03 G   .19510723-01    S  -.89987443 02  SVE   .82871896 01  F  .17960072 03
ELK  .15279896 03 MLK  .15392131 03 SLK  .16097190 03  RM  .10754751 06 RS  .96394885 05        ELLIPSE
ETA  .15283922-01 ZTA -.92468678 00 RHO  .68111805 05  XP  .90856756 05           VEHICLE IS NOT ECLIPSED
XMV  .95273042 05 YMV -.46248614 05 ZMV -.18723811 05  XM  .44351494 04 YM -.47554766 04  ZM -.14986692 04
XSV  .90261663 05 YSV -.31692690 05 ZSV -.11848183 05  XS  .94465283 04 YS -.19311400 05  ZS -.83742974 04

21 JANUARY      HR     MIN  - SEC TIME-START  .26928000 07  JULIAN DATE 3150.5000
LAT(DEG) -.94919560 01  LONG(DEG) .21107815 03   V.APO(FPS) .32523046 02  V.PERI(FPS) .39654945 03
ALT(NM)    .39937948 09  APO(NM)    .33201921 09   PERI(NM)    .27227430 08  PERIOD(MIN) .10064249 10
X  .44154302 01  Y -.20720948 01 Z  -.81004310 00    XD   .18019674-06    YD   .13282584-06 ZD  .66500458-07
R  .49442664 01  A -.25139956 02 D  -.94295545 01     V   .23352919-06 BETA   .66167212 02 AZ  .67111697 02
A  .22237371 01  E  .84840303 00 I   .35027874 02 NODE  -.91697540 01    W  -.19194794 03  M  .31465172 01
R  .93641409-03  V  .35545734-03 G   .15208882-01    S  -.89986608 02  SVE   .66551689 01  F  .18004371 03
ELK  .15486499 03 MLK  .15624202 03 SLK  .16143301 03  RM  .11039895 06 RS  .96407816 05        ELLIPSE
ETA  .16429617-01 ZTA -.10659908 01 RHO  .55637429 05  XP  .10148863 06           VEHICLE IS NOT ECLIPSED
XMV  .99832366 05 YMV -.43693482 05 ZMV -.17672195 05  XM  .37309316 04 YM -.49072109 04  ZM -.13272522 04
XSV  .90533778 05 YSV -.31109686 05 ZSV -.11414446 05  XS  .13029520 05 YS -.17491007 05  ZS -.75850011 04

31 JANUARY      HR     MIN  - SEC TIME-START  .27072000 07  JULIAN DATE 3160.5000
LAT(DEG) -.86314673 01  LONG(DEG) .20326274 03   V.APO(FPS) .32636993 02  V.PERI(FPS) .39493828 03
ALT(NM)    .40507817 09  APO(NM)    .33201858 09   PERI(NM)    .27434263 08  PERIOD(MIN) .10072915 10
X  .45609688 01  Y -.19459942 01 Z  -.74768897 00    XD   .15590476-06    YD   .15845163-06 ZD  .77567337-07
R  .50148149 01  A -.23106122 02 D  -.85745432 01     V   .23543556-06 BETA   .73023275 02 AZ  .66771474 02
A  .22250134 01  E  .84733919 00 I   .34977468 02 NODE  -.91515934 01    W  -.19194786 03  M  .31965372 01
R  .94977554-03  V  .36135718-03 G   .10897861-01    S  -.89985919 02  SVE   .49258325 01  F  .18048994 03
ELK  .15702528 03 MLK  .15880654 03 SLK  .16189421 03  RM  .11228058 06 RS  .96388229 05        ELLIPSE
ETA  .17601788-01 ZTA -.12051239 01 RHO  .41591131 05  XP  .10982803 06           VEHICLE IS NOT ECLIPSED
XMV  .10361841 06 YMV -.40128419 05 ZMV -.16120261 05  XM  .33584746 04 YM -.55146016 04  ZM -.14166796 04
XSV  .90769547 05 YSV -.30513953 05 ZSV -.10976296 05  XS  .16207339 05 YS -.15129067 05  ZS -.65606446 04

10 FEBRUARY     HR     MIN  - SEC TIME-START  .27216000 07  JULIAN DATE 3170.5000
LAT(DEG) -.77303101 01  LONG(DEG) .19549696 03   V.APO(FPS) .32590079 02  V.PERI(FPS) .39558128 03
ALT(NM)    .40895162 09  APO(NM)    .33203365 09   PERI(NM)    .27351528 08  PERIOD(MIN) .10070071 10
X  .46835735 01  Y -.17994656 01 Z  -.67651748 00    XD   .12724708-06    YD   .17999696-06 ZD  .86860862-07
R  .50627673 01  A -.21017165 02 D  -.76791769 01     V   .23692939-06 BETA   .79756635 02 AZ  .66403935 02
A  .22245945 01  E  .84777086 00 I   .35018166 02 NODE  -.91655643 01    W  -.19197358 03  M  .32527319 01
R  .95885745-03  V  .36564150-03 G   .66014352-02    S  -.89985374 02  SVE   .31305070 01  F  .18098971 03
ELK  .15925072 03 MLK  .16150408 03 SLK  .16235681 03  RM  .11309572 06 RS  .96332128 05        ELLIPSE
ETA  .18817618-01 ZTA -.13424437 01 RHO  .26429759 05  XP  .11564343 06           VEHICLE IS NOT ECLIPSED
XMV  .10634663 06 YMV -.35786481 05 ZMV -.14154979 05  XM  .35059326 04 YM -.64197324 04  ZM -.17126436 04
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XSV  .90965616 05 YSV -.29903238 05 ZSV -.10532427 05  XS  .18886946 05 YS -.12302976 05  ZS -.53351963 04

20 FEBRUARY      HR     MIN  - SEC TIME-START  .27360000 07  JULIAN DATE 3180.5000
LAT(DEG) -.67975247 01  LONG(DEG) .18775596 03   V.APO(FPS) .32534361 02  V.PERI(FPS) .39640171 03
ALT(NM)    .41094691 09  APO(NM)    .33200931 09   PERI(NM)    .27246244 08  PERIOD(MIN) .10064624 10
X  .47798517 01  Y -.16363163 01 Z   -.59818283 00   XD    .95119136-07   YD    .19683715-06 ZD  .94110336-07
R  .50874685 01  A -.18897931 02 D   -.67524384 01    V    .23801107-06 BETA    .86388575 02 AZ  .66019217 02
A  .22237922 01  E   .84830205 00 I    .35016154 02 NODE  -.91650255 01     W  -.19193706 03  M  .33007060 01
R  .96353570-03  V   .36817953-03 G    .23328568-02    S  -.89984975 02  SVE    .13049136 01  F  .18141466 03
ELK  .16151382 03 MLK  .16422589 03 SLK  .16281871 03  RM  .11280708 06 RS  .96241062 05        ELLIPSE
ETA  .20094085-01 ZTA -.14783948 01 RHO  .10712171 05  XP  .11879283 06       VEHICLE IS NOT ECLIPSED
XMV  .10781839 06 YMV -.30968284 05 ZMV -.11899481 05  XM  .42923643 04 YM -.74112849 04  ZM -.21308137 04
XSV  .91121962 05 YSV -.29281798 05 ZSV -.10084975 05  XS  .20988792 05 YS -.90977710 04  ZS -.39453198 04

 1 MARCH         HR     MIN  - SEC TIME-START  .27504000 07  JULIAN DATE 3190.5000
LAT(DEG) -.58422472 01  LONG(DEG) .18002234 03   V.APO(FPS) .32660175 02  V.PERI(FPS) .39461035 03
ALT(NM)    .41104215 09  APO(NM)    .33201956 09   PERI(NM)    .27476650 08  PERIOD(MIN) .10074738 10
X  .48472255 01  Y -.14608174 01 Z   -.51454054 00   XD    .60506912-07   YD    .20852455-06 ZD  .99121345-07
R  .50886476 01  A -.16771328 02 D   -.58034024 01    V    .23868099-06 BETA    .92941530 02 AZ  .65621944 02
A  .22252818 01  E   .84712180 00 I    .34977694 02 NODE  -.91527561 01     W  -.19195300 03  M  .33534385 01
R  .96375901-03  V   .36894130-03 G   -.19020972-02    S  -.89984720 02  SVE    .65805627 00  F  .18189429 03
ELK  .16378782 03 MLK  .16686877 03 SLK  .16328246 03  RM  .11143024 06 RS  .96117015 05        ELLIPSE
ETA  .21448366-01 ZTA  .46700497 01 RHO  .51064180 04  XP  .11921913 06       VEHICLE IS NOT ECLIPSED
XMV  .10793670 06 YMV -.26003618 05 ZMV -.94963085 04  XM  .57542998 04 YM -.82596489 04  ZM -.25721680 04
XSV  .91241596 05 YSV -.28647102 05 ZSV -.96330426 04  XS  .22449401 05 YS -.56161655 04  ZS -.24354338 04

11 MARCH         HR     MIN  - SEC TIME-START  .27648000 07  JULIAN DATE 3200.5000
LAT(DEG) -.48737286 01  LONG(DEG) .17228551 03   V.APO(FPS) .32553263 02  V.PERI(FPS) .39609001 03
ALT(NM)    .40924457 09  APO(NM)    .33204319 09   PERI(NM)    .27286316 08  PERIOD(MIN) .10067731 10
X  .48839936 01  Y -.12775488 01 Z   -.42758006 00   XD    .24457740-07   YD    .21479183-06 ZD  .10177798-06
R  .50663940 01  A -.14658909 02 D   -.48412556 01    V    .23894030-06 BETA    .99436316 02 AZ  .65211626 02
A  .22242499 01  E   .84811024 00 I    .35027624 02 NODE  -.91678432 01     W  -.19196388 03  M  .34077370 01
R  .95954431-03  V   .36790676-03 G   -.61006836-02    S  -.89984609 02  SVE    .24634716 01  F  .18237298 03
ELK  .16604580 03 MLK  .16932684 03 SLK  .16374791 03  RM  .10902591 06 RS  .95955475 05        ELLIPSE
ETA  .22898262-01 ZTA  .45361545 01 RHO  .20460109 05  XP  .11696029 06       VEHICLE IS NOT ECLIPSED
XMV  .10670247 06 YMV -.21232908 05 ZMV -.70989191 04  XM  .78509121 04 YM -.87318196 04  ZM -.29299114 04
XSV  .91319787 05 YSV -.27999028 05 ZSV -.91762765 04  XS  .23233599 05 YS -.19656999 04  ZS -.85255408 03

21 MARCH         HR     MIN  - SEC TIME-START  .27792000 07  JULIAN DATE 3210.5000
LAT(DEG) -.39013644 01  LONG(DEG) .16450273 03   V.APO(FPS) .32565811 02  V.PERI(FPS) .39598462 03
ALT(NM)    .40559037 09  APO(NM)    .33198715 09   PERI(NM)    .27299492 08  PERIOD(MIN) .10065930 10
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X    .48893789 01  Y -.10912452 01 Z   -.33935799 00    XD  -.11965176-07    YD   .21555047-06 ZD  .10204185-06
R    .50211558 01  A -.12581466 02 D   -.38753255 01     V   .23878381-06 BETA   .10589405 03 AZ  .64782469 02
A    .22239847 01  E   .84801877 00 I    .35000555 02 NODE -.91601750 01     W  -.19193277 03  M   .34552949 01
R    .95097648-03  V   .36510527-03 G  -.10262229-01     S  -.89984644 02  SVE   .42837734 01  F   .18280155 03
ELK  .16825918 03 MLK  .17149247 03 SLK  .16421387 03  RM  .10571336 06 RS  .95760052 05           ELLIPSE
ETA  .24462565-01 ZTA  .44026437 01 RHO  .35480132 05  XP  .11213240 06            VEHICLE IS NOT ECLIPSED
XMV  .10422739 06 YMV -.16980538 05 ZMV -.48608016 04  XM  .10452306 05 YM -.86144648 04  ZM -.30987925 04
XSV  .91359078 05 YSV -.27340945 05 ZSV -.87166149 04  XS  .23320621 05 YS  .17459426 04  ZS  .75702069 03

31 MARCH         HR    MIN  - SEC TIME-START  .27936000 07  JULIAN DATE 3220.5000
LAT(DEG) -.29347672 01  LONG(DEG) .15666976 03   V.APO(FPS) .32654462 02  V.PERI(FPS) .39466176 03
ALT(NM)    .40014175 09  APO(NM)    .33204214 09   PERI(NM)    .27470132 08  PERIOD(MIN) .10075413 10
X    .48635080 01  Y -.90664080 00 Z   -.25193088 00    XD  -.47728765-07    YD   .21088640-06 ZD  .99949897-07
R    .49537033 01  A -.10559702 02 D   -.29151536 01     V   .23820388-06 BETA   .11233952 03 AZ  .64322391 02
A    .22253813 01  E   .84716488 00 I    .34988639 02 NODE -.91567615 01     W  -.19197653 03  M   .35105137 01
R    .93820139-03  V   .36057119-03 G  -.14387365-01     S  -.89984828 02  SVE   .60539825 01  F   .18331189 03
ELK  .17039524 03 MLK  .17326697 03 SLK  .16468324 03  RM  .10165926 06 RS  .95530244 05           ELLIPSE
ETA  .26161480-01 ZTA  .42692991 01 RHO  .49400046 05  XP  .10493233 06            VEHICLE IS NOT ECLIPSED
XMV  .10071406 06 YMV -.13519235 05 ZMV -.29176009 04  XM  .13358837 05 YM -.77458984 04  ZM -.29914028 04
XSV  .91360160 05 YSV -.26669204 05 ZSV -.82524109 04  XS  .22712740 05 YS  .54040710 04  ZS  .23434072 04

10 APRIL         HR    MIN  - SEC TIME-START  .28080000 07  JULIAN DATE 3230.5000
LAT(DEG) -.19838372 01  LONG(DEG) .14875436 03   V.APO(FPS) .32529941 02  V.PERI(FPS) .39643150 03
ALT(NM)    .39298583 09  APO(NM)    .33203479 09   PERI(NM)    .27242585 08  PERIOD(MIN) .10065540 10
X    .48073794 01  Y -.72832429 00 Z   -.16729227 00    XD  -.81848984-07    YD   .20104792-06 ZD  .95609899-07
R    .48651145 01  A -.86148729 01 D   -.19705663 01     V   .23719354-06 BETA   .11879835 03 AZ  .63810825 02
A    .22239273 01  E   .84833163 00 I    .35029311 02 NODE -.91673471 01     W  -.19194924 03  M   .35621681 01
R    .92142320-03  V   .35438551-03 G  -.18474077-01     S  -.89985167 02  SVE   .77484602 01  F   .18376457 03
ELK  .17241231 03 MLK  .17456756 03 SLK  .16515455 03  RM  .97077543 05 RS  .95262772 05           ELLIPSE
ETA  .28017011-01 ZTA  .41356447 01 RHO  .61835902 05  XP  .95614789 05            VEHICLE IS NOT ECLIPSED
XMV  .96435265 05 YMV -.11062416 05 ZMV -.13828358 04  XM  .16321147 05 YM -.60203287 04  ZM -.25409811 04
XSV  .91318793 05 YSV -.25986058 05 ZSV -.77845278 04  XS  .21437619 05 YS  .89033137 04  ZS  .38607109 04

20 APRIL         HR    MIN  - SEC TIME-START  .28224000 07  JULIAN DATE 3240.5000
LAT(DEG) -.10588854 01  LONG(DEG) .14075050 03   V.APO(FPS) .32608757 02  V.PERI(FPS) .39539990 03
ALT(NM)    .38423379 09  APO(NM)    .33196959 09   PERI(NM)    .27374480 08  PERIOD(MIN) .10068344 10
X    .47228085 01  Y -.56060996 00 Z   -.87316666-01    XD  -.11342009-06    YD   .18642213-06 ZD  .89189513-07
R    .47567665 01  A -.67694855 01 D   -.10517980 01     V   .23573734-06 BETA   .12529874 03 AZ  .63214635 02
A    .22243401 01  E   .84762571 00 I    .34985328 02 NODE -.91566955 01     W  -.19193934 03  M   .36106904 01
R    .90090274-03  V   .34665377-03 G  -.22514934-01     S  -.89985667 02  SVE   .93409094 01  F   .18421939 03
ELK  .17424845 03 MLK  .17533498 03 SLK  .16562799 03  RM  .92240850 05 RS  .94961806 05           ELLIPSE
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ETA  .30053289-01 ZTA  .40011080 01 RHO  .72483031 05  XP  .84478508 05              VEHICLE IS NOT ECLIPSED
XMV  .91724263 05 YMV -.97426916 04 ZMV -.33754419 03  XM  .19048550 05 YM -.34063365 04  ZM -.17104560 04
XSV  .91238812 05 YSV -.25292853 05 ZSV -.73140540 04  XS  .19534000 05 YS  .12143825 05  ZS  .52660538 04

30 APRIL        HR    MIN  - SEC TIME-START  .28368000 07  JULIAN DATE 3250.5000
LAT(DEG) -.17078475 00  LONG(DEG) .13261177 03  V.APO(FPS) .32623873 02  V.PERI(FPS) .39505112 03
ALT(NM)   .37402080 09  APO(NM)   .33207466 09  PERI(NM)   .27420030 08  PERIOD(MIN) .10074674 10
X  .46123524 01  Y -.40742136 00 Z  -.13709471-01   XD  -.14164605-06   YD  .16751708-06 ZD  .80908803-07
R  .46303320 01  A -.50479865 01 D  -.16964139 00    V   .23382004-06 BETA  .13187456 03 AZ  .62479720 02
A  .22252724 01  E  .84743614 00 I   .35005264 02 NODE  -.91611093 01   W  -.19198090 03  M  .36670974 01
R  .87695682-03  V  .33750940-03 G  -.26496385-01    S  -.89986341 02  SVE  .10801283 02  F  .18474264 03
ELK  .17579434 03 MLK  .17548112 03 SLK  .16610606 03  RM  .87463891 05 RS  .94624474 05          ELLIPSE
ETA  .32296663-01 ZTA  .38653205 01 RHO  .81079017 05  XP  .71878046 05              VEHICLE IS NOT ECLIPSED
XMV  .86935291 05 YMV -.95997739 04 ZMV  .17809217 03  XM  .21246791 05 YM  .43762817 02  ZM -.49964590 03
XSV  .91118252 05 YSV -.24586179 05 ZSV -.68392367 04  XS  .17063830 05 YS  .15030168 05  ZS  .65176829 04

10 MAY          HR    MIN  - SEC TIME-START  .28512000 07  JULIAN DATE 3260.5000
LAT(DEG)  .66881691 00  LONG(DEG) .12432749 03  V.APO(FPS) .32527084 02  V.PERI(FPS) .39651038 03
ALT(NM)   .36250507 09  APO(NM)   .33200511 09  PERI(NM)   .27232337 08  PERIOD(MIN) .10063863 10
X  .44792053 01  Y -.27219729 00 Z   .52034148-01   XD  -.16584308-06   YD  .14494561-06 ZD  .71033611-07
R  .44877699 01  A -.34775366 01 D   .66433973 00    V   .23142803-06 BETA  .13856169 03 AZ  .61513839 02
A  .22236801 01  E  .84837183 00 I   .35023325 02 NODE  -.91651035 01   W  -.19193502 03  M  .37163834 01
R  .84995642-03  V  .32711196-03 G  -.30389924-01    S  -.89987203 02  SVE  .12101810 02  F  .18518051 03
ELK  .17684052 03 MLK  .17482329 03 SLK  .16658655 03  RM  .83100272 05 RS  .94249799 05          ELLIPSE
ETA  .34775843-01 ZTA  .37276046 01 RHO  .87449263 05  XP  .58178092 05              VEHICLE IS NOT ECLIPSED
XMV  .82422472 05 YMV -.10590828 05 ZMV  .16076590 03  XM  .22636663 05 YM  .42064785 04  ZM  .10596878 04
XSV  .90954811 05 YSV -.23869916 05 ZSV -.63619255 04  XS  .14104323 05 YS  .17485567 05  ZS  .75823791 04

20 MAY          HR    MIN  - SEC TIME-START  .28656000 07  JULIAN DATE 3270.5000
LAT(DEG)  .14472605 01  LONG(DEG) .11585611 03  V.APO(FPS) .32645289 02  V.PERI(FPS) .39487253 03
ALT(NM)   .34986908 09  APO(NM)   .33197882 09  PERI(NM)   .27442519 08  PERIOD(MIN) .10071591 10
X  .43270994 01  Y -.15781191 00 Z   .10866375 00   XD  -.18545098-06   YD  .11939744-06 ZD  .59862658-07
R  .43313394 01  A -.20886856 01 D   .14375755 01    V   .22854179-06 BETA  .14539858 03 AZ  .60146652 02
A  .22248184 01  E  .84727987 00 I   .34977277 02 NODE  -.91558901 01   W  -.19195615 03  M  .37670761 01
R  .82032944-03  V  .31564687-03 G  -.34147990-01    S  -.89988272 02  SVE  .13207290 02  F  .18567876 03
ELK  .17712625 03 MLK  .17324165 03 SLK  .16707121 03  RM  .79522948 05 RS  .93841183 05          ELLIPSE
ETA  .37521446-01 ZTA  .35871924 01 RHO  .91480910 05  XP  .43754796 05              VEHICLE IS NOT ECLIPSED
XMV  .78520398 05 YMV -.12582661 05 ZMV -.35079590 03  XM  .22971113 05 YM  .88812052 04  ZM  .28994889 04
XSV  .90752266 05 YSV -.23142949 05 ZSV -.58820116 04  XS  .10739246 05 YS  .19441493 05  ZS  .84307045 04

30 MAY          HR    MIN  - SEC TIME-START  .28800000 07  JULIAN DATE 3280.5000
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LAT(DEG)  .21505464 01  LONG(DEG) .10717947 03   V.APO(FPS) .32582808 02  V.PERI(FPS) .39560422 03
ALT(NM)    .33632092 09  APO(NM)    .33209558 09   PERI(NM)    .27348941 08  PERIOD(MIN) .10072565 10
X  .41601912 01  Y -.66521714-01 Z   .15519643 00   XD  -.20004682-06   YD   .91616503-07 ZD  .47718377-07
R  .41636164 01  A -.91608501 00 D   .21361624 01    V   .22514297-06 BETA  .15242462 03 AZ  .58021903 02
A  .22249619 01  E  .84781039 00 I   .35019912 02 NODE  -.91636727 01    W  -.19197365 03  M  .38228434 01
R  .78856370-03  V  .30332495-03 G  -.37697584-01    S  -.89989572 02  SVE  .14079151 02  F  .18619273 03
ELK  .17674872 03 MLK  .17086309 03 SLK  .16756129 03  RM  .77064813 05 RS  .93394164 05          ELLIPSE
ETA  .40564978-01 ZTA  .34434752 01 RHO  .93112248 05  XP  .29011321 05          VEHICLE IS NOT ECLIPSED
XMV  .75506474 05 YMV -.15366196 05 ZMV -.12798377 04  XM  .22070228 05 YM  .13805939 05  ZM  .49199484 04
XSV  .90506399 05 YSV -.22403548 05 ZSV -.53983889 04  XS  .70703027 04 YS  .20843290 05  ZS  .90384994 04

 9 JUNE        HR     MIN   - SEC TIME-START  .28944000 07  JULIAN DATE 3290.5000
LAT(DEG)  .27630832 01  LONG(DEG) .98236554 02   V.APO(FPS) .32544791 02  V.PERI(FPS) .39631740 03
ALT(NM)    .32209642 09  APO(NM)    .33196009 09   PERI(NM)    .27256737 08  PERIOD(MIN) .10062996 10
X  .39829462 01  Y  .85563576-04 Z   .19093931 00   XD  -.20934237-06   YD   .62393249-07 ZD  .34943514-07
R  .39875204 01  A  .12308556-02 D   .27446133 01    V   .22121979-06 BETA  .15966125 03 AZ  .54245396 02
A  .22235525 01  E  .84822728 00 I   .35010937 02 NODE  -.91622853 01    W  -.19192613 03  M  .38707124 01
R  .75521219-03  V  .29038265-03 G  -.40928421-01    S  -.89991134 02  SVE  .14677576 02  F  .18663761 03
ELK  .17614910 03 MLK  .16801675 03 SLK  .16805483 03  RM  .75968361 05 RS  .92910277 05          ELLIPSE
ETA  .43936825-01 ZTA  .32954968 01 RHO  .92355736 05  XP  .14323555 05          VEHICLE IS NOT ECLIPSED
XMV  .73593305 05 YMV -.18677802 05 ZMV -.25213365 04  XM  .19826143 05 YM  .18679809 05  ZM  .69997913 04
XSV  .90217558 05 YSV -.21655755 05 ZSV -.49132436 04  XS  .32018887 04 YS  .21657762 05  ZS  .93916985 04

19 JUNE        HR     MIN   - SEC TIME-START  .29088000 07  JULIAN DATE 3300.5000
LAT(DEG)  .32673993 01  LONG(DEG) .89000455 02   V.APO(FPS) .32658504 02  V.PERI(FPS) .39462841 03
ALT(NM)    .30746187 09  APO(NM)    .33202382 09   PERI(NM)    .27474338 08  PERIOD(MIN) .10074820 10
X  .38000205 01  Y  .41112973-01 Z   .21549877 00   XD  -.21318099-06   YD   .32538456-07 ZD  .21889182-07
R  .38063481 01  A  .61986715 00 D   .32455717 01    V   .21675798-06 BETA  .16703928 03 AZ  .45783424 02
A  .22252938 01  E  .84713548 00 I   .34980848 02 NODE  -.91575322 01    W  -.19197564 03  M  .39240911 01
R  .72089926-03  V  .27708257-03 G  -.43679752-01    S  -.89992988 02  SVE  .14953407 02  F  .18718306 03
ELK  .17564704 03 MLK  .16513809 03 SLK  .16855466 03  RM  .76318692 05 RS  .92390936 05          ELLIPSE
ETA  .47662535-01 ZTA  .31422294 01 RHO  .89276078 05  XP  .56784409 02          VEHICLE IS NOT ECLIPSED
XMV  .72910295 05 YMV -.22205520 05 ZMV -.39429335 04  XM  .16218655 05 YM  .23169819 05  ZM  .89974271 04
XSV  .89887892 05 YSV -.20896594 05 ZSV -.44254138 04  XS -.75894238 03 YS  .21860893 05  ZS  .94799073 04

29 JUNE        HR     MIN   - SEC TIME-START  .29232000 07  JULIAN DATE 3310.5000
LAT(DEG)  .36440307 01  LONG(DEG) .79413345 02   V.APO(FPS) .32547768 02  V.PERI(FPS) .39611132 03
ALT(NM)    .29271749 09  APO(NM)    .33208699 09   PERI(NM)    .27283841 08  PERIOD(MIN) .10069468 10
X  .36161477 01  Y  .56364184-01 Z   .22878479 00   XD  -.21154339-06   YD   .28627631-08 ZD  .89068244-08
R  .36238161 01  A  .89298577 00 D   .36196997 01    V   .21175017-06 BETA  .17374326 03 AZ  .15479825 02
A  .22245057 01  E  .84814148 00 I   .35027776 02 NODE  -.91640568 01    W  -.19195752 03  M  .39777819 01
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R   .68632881-03  V   .26370974-03 G   -.45730660-01     S  -.89995167 02  SVE    .14857030 02  F  .18767620 03
ELK  .17540869 03 MLK  .16264955 03 SLK  .16906057 03  RM  .78010212 05 RS  .91831560 05          ELLIPSE
ETA  .51756666-01 ZTA  .29828067 01 RHO  .83991191 05  XP -.13421548 05              VEHICLE IS NOT ECLIPSED
XMV  .73484506 05 YMV -.25621747 05 ZMV -.53987786 04  XM  .11331732 05 YM  .26943761 05  ZM  .10764894 05
XSV  .89512401 05 YSV -.20126649 05 ZSV -.39349133 04  XS -.46961631 04 YS  .21448563 05  ZS  .93010286 04

 9 JULY         HR     MIN  - SEC TIME-START  .29376000 07  JULIAN DATE 3320.5000
LAT(DEG)   .38718324 01  LONG(DEG) .69443857 02   V.APO(FPS) .32577598 02  V.PERI(FPS) .39590663 03
ALT(NM)    .27819955 09  APO(NM)   .33191832 09   PERI(NM)   .27309091 08  PERIOD(MIN) .10063441 10
X  .34360188 01  Y   .46344296-01 Z    .23101142 00   XD  -.20454448-06   YD  -.25825760-07 ZD -.36533786-08
R  .34440876 01  A   .77274653 00 D    .38459893 01    V   .20620077-06 BETA  .17298643 03 AZ -.66358351 02
A  .22236180 01  E   .84794027 00 I    .34996806 02 NODE  -.91603533 01    W  -.19192714 03  M  .40255560 01
R  .65228931-03  V   .25059623-03 G   -.46791227-01    S  -.89997690 02  SVE   .14338128 02  F  .18815385 03
ELK  .17553333 03 MLK  .16086444 03 SLK  .16957165 03  RM  .80786952 05 RS  .91235484 05          ELLIPSE
ETA  .56213488-01 ZTA  .28160582 01 RHO  .76670800 05  XP -.25794055 05              VEHICLE IS NOT ECLIPSED
XMV  .75251545 05 YMV -.28605935 05 ZMV -.67407066 04  XM  .53397949 04 YM  .29692934 05  ZM  .12159047 05
XSV  .89093667 05 YSV -.19348755 05 ZSV -.34435285 04  XS -.85023271 04 YS  .20435754 05  ZS  .88618690 04

19 JULY         HR     MIN  - SEC TIME-START  .29520000 07  JULIAN DATE 3330.5000
LAT(DEG)   .39290310 01  LONG(DEG) .59025863 02   V.APO(FPS) .32642859 02  V.PERI(FPS) .39476313 03
ALT(NM)    .26428117 09  APO(NM)   .33209040 09   PERI(NM)   .27457308 08  PERIOD(MIN) .10076903 10
X  .32641709 01  Y   .12247539-01 Z    .22269117 00   XD  -.19242458-06   YD  -.52744025-07 ZD -.15452352-07
R  .32717813 01  A   .21497925 00 D    .39028086 01    V   .20011978-06 BETA  .16491759 03 AZ  .26746196 03
A  .22256006 01  E   .84725128 00 I    .34994324 02 NODE  -.91599165 01    W  -.19198791 03  M  .40810783 01
R  .61965554-03  V   .23806064-03 G   -.46500700-01    S   .26999944 03  SVE   .13345730 02  F  .18873371 03
ELK  .17608911 03 MLK  .15994562 03 SLK  .17009110 03  RM  .84291683 05 RS  .90601553 05          ELLIPSE
ETA  .60993757-01 ZTA  .26409172 01 RHO  .67527651 05  XP -.36767695 05              VEHICLE IS NOT ECLIPSED
XMV  .78048124 05 YMV -.30860329 05 ZMV -.78242125 04  XM -.14874531 04 YM  .31147593 05  ZM  .13047403 05
XSV  .88631250 05 YSV -.18559184 05 ZSV -.29495315 04  XS -.12070579 05 YS  .18846448 05  ZS  .81727217 04

29 JULY         HR     MIN  - SEC TIME-START  .29664000 07  JULIAN DATE 3340.5000
LAT(DEG)   .37954770 01  LONG(DEG) .48142878 02   V.APO(FPS) .32530147 02  V.PERI(FPS) .39642028 03
ALT(NM)    .25136864 09  APO(NM)   .33204120 09   PERI(NM)   .27244054 08  PERIOD(MIN) .10065872 10
X  .31048797 01  Y  -.44074573-01 Z    .20462133 00   XD  -.17554973-06   YD  -.77153959-07 ZD -.26170120-07
R  .31119271 01  A  -.81327385 00 D    .37701406 01    V   .19353376-06 BETA  .15526687 03 AZ  .25958100 03
A  .22239760 01  E   .84832678 00 I    .35026925 02 NODE  -.91629971 01    W  -.19193801 03  M  .41321583 01
R  .58938014-03  V   .22649240-03 G   -.44462944-01    S   .26999629 03  SVE   .11845167 02  F  .18921267 03
ELK  .17711540 03 MLK  .15991142 03 SLK  .17061743 03  RM  .88137490 05 RS  .89926485 05          ELLIPSE
ETA  .66008539-01 ZTA  .24567220 01 RHO  .56826072 05  XP -.46070821 05              VEHICLE IS NOT ECLIPSED
XMV  .81621880 05 YMV -.32146406 05 ZMV -.85261127 04  XM -.87973603 04 YM  .31112643 05  ZM  .13325477 05
XSV  .88120970 05 YSV -.17760759 05 ZSV -.24541701 04  XS -.15296450 05 YS  .16726996 05  ZS  .72535347 04
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 8 AUGUST        HR     MIN   - SEC TIME-START  .29808000 07  JULIAN DATE 3350.5000
LAT(DEG)   .34566750 01  LONG(DEG) .36778543 02   V.APO(FPS) .32615862 02  V.PERI(FPS) .39538056 03
ALT(NM)    .23988940 09   APO(NM)   .33190677 09   PERI(NM)    .27376601 08  PERIOD(MIN) .10065793 10
X  .29620498 01  Y -.12015253 00 Z    .17786699 00   XD  -.15441169-06   YD   -.98364868-07 ZD -.35507657-07
R  .29698168 01  A -.23228713 01 D    .34335888 01    V    .18649238-06 BETA   .14467415 03 AZ  .25580565 03
A  .22239644 01  E   .84758816 00 I   .34985432 02 NODE  -.91599286 01     W  -.19194060 03  M   .41811998 01
R  .56246531-03  V   .21625800-03 G  -.40308588-01    S    .26999299 03  SVE    .98234717 01  F   .18974665 03
ELK  .17856974 03 MLK   .16069199 03 SLK  .17115133 03  RM  .91964005 05 RS  .89214091 05          ELLIPSE
ETA  .71103735-01 ZTA   .22629205 01 RHO  .44863990 05  XP -.53492590 05            VEHICLE IS NOT ECLIPSED
XMV  .85660591 05 YMV -.32296368 05 ZMV -.87513425 04  XM -.16186128 05 YM  .29478207 05  ZM  .12923188 05
XSV  .87566414 05 YSV -.16954131 05 ZSV -.19582354 04  XS -.18091951 05 YS  .14135970 05  ZS  .61300807 04

18 AUGUST        HR     MIN   - SEC TIME-START  .29952000 07  JULIAN DATE 3360.5000
LAT(DEG)   .29096583 01  LONG(DEG) .24957238 02   V.APO(FPS) .32606315 02  V.PERI(FPS) .39520480 03
ALT(NM)    .23026851 09   APO(NM)   .33214777 09   PERI(NM)    .27400644 08  PERIOD(MIN) .10076932 10
X  .28391116 01  Y -.21294765 00 Z    .14373955 00   XD  -.12961302-06   YD   -.11575457-06 ZD -.43195628-07
R  .28507126 01  A -.42894400 01 D    .28902119 01    V    .17906568-06 BETA   .13321661 03 AZ  .25350146 03
A  .22256049 01  E   .84756677 00 I   .35010279 02 NODE  -.91612362 01     W  -.19198640 03  M   .42374668 01
R  .53990768-03  V   .20772099-03 G  -.33818604-01    S    .26998977 03  SVE    .73078934 01  F   .19033776 03
ELK  .17890522 03 MLK   .16217249 03 SLK  .17169558 03  RM  .95449871 05 RS  .88460850 05          ELLIPSE
ETA  .76053033-01 ZTA   .20596913 01 RHO  .31993902 05  XP -.58859578 05            VEHICLE IS NOT ECLIPSED
XMV  .89801729 05 YMV -.31226664 05 ZMV -.84393596 04  XM -.23210765 05 YM  .26232006 05  ZM  .11810751 05
XSV  .86964431 05 YSV -.16136230 05 ZSV -.14601434 04  XS -.20373466 05 YS  .11141572 05  ZS  .48315345 04

28 AUGUST        HR     MIN   - SEC TIME-START  .30096000 07  JULIAN DATE 3370.5000
LAT(DEG)   .21696294 01  LONG(DEG) .12750314 02   V.APO(FPS) .32533388 02  V.PERI(FPS) .39646729 03
ALT(NM)    .22289151 09   APO(NM)   .33196925 09   PERI(NM)    .27237635 08  PERIOD(MIN) .10062578 10
X  .27389301 01  Y -.31892167 00 Z    .10376685 00   XD  -.10186098-06   YD   -.12879058-06 ZD -.49003346-07
R  .27593870 01  A -.66416253 01 D    .21551179 01    V    .17135927-06 BETA   .12092467 03 AZ  .25187753 03
A  .22234909 01  E   .84832943 00 I   .35019222 02 NODE  -.91617503 01     W  -.19192221 03  M   .42864328 01
R  .52261118-03  V   .20121508-03 G  -.25075961-01    S    .26998698 03  SVE    .44074023 01  F   .19082648 03
ELK  .17662884 03 MLK   .16421853 03 SLK  .17224805 03  RM  .98335017 05 RS  .87665760 05          ELLIPSE
ETA  .80571040-01 ZTA   .18483018 01 RHO  .18712710 05  XP -.62042998 05            VEHICLE IS NOT ECLIPSED
XMV  .93668943 05 YMV -.28957102 05 ZMV -.75757066 04  XM -.29427720 05 YM  .21476839 05  ZM  .10009544 05
XSV  .86312963 05 YSV -.15311189 05 ZSV -.96201849 03  XS -.22071739 05 YS  .78309258 04  ZS  .33958555 04

 7 SEPTEMBER     HR     MIN   - SEC TIME-START  .30240000 07  JULIAN DATE 3380.5000
LAT(DEG)   .12748427 01  LONG(DEG) .28083347 00   V.APO(FPS) .32643785 02  V.PERI(FPS) .39493233 03
ALT(NM)    .21805532 09   APO(NM)   .33194885 09   PERI(NM)    .27434622 08  PERIOD(MIN) .10070000 10
X  .26637136 01  Y -.43411740 00 Z    .59657933-01   XD  -.71966608-07   YD   -.13703749-06 ZD -.52742718-07
R  .26995161 01  A -.92563717 01 D    .12663107 01    V    .16352449-06 BETA   .10785581 03 AZ  .25062062 03
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A  .22245840 01  E  .84730773 00 I   .34981670 02 NODE  -.91607733 01     W  -.19196335 03   M  .43376760 01
R  .51127197-03  V  .19695057-03 G  -.14586664-01    S   .26998497 03  SVE   .16088280 01   F  .19142993 03
ELK  .17389548 03 MLK  .16670033 03 SLK  .17281116 03  RM  .10042149 06 RS  .86831613 05          ELLIPSE
ETA  .84355933-01 ZTA  .16307463 01 RHO  .68304008 04  XP -.62978284 05        VEHICLE IS NOT ECLIPSED
XMV  .96906850 05 YMV -.25597851 05 ZMV -.61877482 04  XM -.34429820 05 YM  .15415688 05  ZM  .75870167 04
XSV  .85614955 05 YSV -.14477353 05 ZSV -.46346313 03  XS -.23137926 05 YS  .42951903 04  ZS  .18627316 04

17 SEPTEMBER    HR    MIN  - SEC TIME-START  .30384000 07  JULIAN DATE 3390.5000
LAT(DEG)  .28621433 00  LONG(DEG) .34771541 03   V.APO(FPS) .32567123 02  V.PERI(FPS) .39574087 03
ALT(NM)   .21591819 09  APO(NM)   .33216169 09   PERI(NM)   .27331773 08  PERIOD(MIN) .10074623 10
X  .26149332 01  Y -.55424976 00 Z   .13263504-01   XD  -.40819495-07    YD  -.14017552-06 ZD -.54275522-07
R  .26730590 01  A -.11967052 02 D   .28429821 00    V   .15576020-06 BETA   .94099928 02 AZ  .24957393 03
A  .22252648 01  E  .84792662 00 I   .35022561 02 NODE  -.91610275 01     W  -.19197107 03   M  .43929604 01
R  .50626116-03  V  .19506594-03 G  -.32712088-02    S   .26998407 03  SVE   .28524185 01   F  .19201320 03
ELK  .17101982 03 MLK  .16949045 03 SLK  .17338651 03  RM  .10156200 06 RS  .85953453 05          ELLIPSE
ETA  .87157193-01 ZTA  .14100232 01 RHO  .11676841 05  XP -.61652770 05        VEHICLE IS NOT ECLIPSED
XMV  .99198094 05 YMV -.21347155 05 ZMV -.43448809 04  XM -.37865201 05 YM  .83473041 04  ZM  .46559745 04
XSV  .84865316 05 YSV -.13633525 05 ZSV  .36270271 02  XS -.23532424 05 YS  .63367383 03  ZS  .27482336 03

27 SEPTEMBER    HR    MIN  - SEC TIME-START  .30528000 07  JULIAN DATE 3400.5000
LAT(DEG) -.72046932 00  LONG(DEG) .33524179 03   V.APO(FPS) .32555151 02  V.PERI(FPS) .39626010 03
ALT(NM)   .21646560 09  APO(NM)   .33189077 09   PERI(NM)   .27263662 08  PERIOD(MIN) .10060374 10
X  .25932651 01  Y -.67481515 00 Z  -.33471313-01   XD  -.93699735-08    YD  -.13802139-06 ZD -.53522768-07
R  .26798357 01  A -.14585933 02 D  -.71564644 00    V   .14833201-06 BETA   .79764933 02 AZ  .24862695 03
A  .22231662 01  E  .84816234 00 I   .35007565 02 NODE  -.91613018 01     W  -.19191561 03   M  .44409599 01
R  .50754464-03  V  .19553739-03 G   .77229153-02    S   .26998441 03  SVE   .60358227 01   F  .19254386 03
ELK  .16821841 03 MLK  .17245484 03 SLK  .17397240 03  RM  .10167087 06 RS  .85032652 05          ELLIPSE
ETA  .88843425-01 ZTA  .11897350 01 RHO  .24209247 05  XP -.58117644 05        VEHICLE IS NOT ECLIPSED
XMV  .10030325 06 YMV -.16479522 05 ZMV -.21561613 04  XM -.39478585 05 YM  .65182703 03  ZM  .13710964 04
XSV  .84064521 05 YSV -.12783670 05 ZSV  .53488729 03  XS -.23239852 05 YS -.30440251 04  ZS -.13199523 04

 7 OCTOBER      HR    MIN  - SEC TIME-START  .30672000 07  JULIAN DATE 3410.5000
LAT(DEG) -.16677863 01  LONG(DEG) .32302734 03   V.APO(FPS) .32647744 02  V.PERI(FPS) .39475664 03
ALT(NM)   .21950504 09  APO(NM)   .33204196 09   PERI(NM)   .27457863 08  PERIOD(MIN) .10074890 10
X  .25985408 01  Y -.79121464 00 Z  -.78560688-01   XD   .21380776-07    YD  -.13053879-06 ZD -.50469626-07
R  .27174632 01  A -.16934664 02 D  -.16566270 01    V   .14157930-06 BETA   .64965281 02 AZ  .24766038 03
A  .22253042 01  E  .84722785 00 I   .34987713 02 NODE  -.91617304 01     W  -.19198554 03   M  .44945994 01
R  .51467106-03  V  .19820861-03 G   .17319716-01    S   .26998590 03  SVE   .90907153 01   F  .19321427 03
ELK  .16568892 03 MLK  .17541371 03 SLK  .17457252 03  RM  .10071285 06 RS  .84069845 05          ELLIPSE
ETA  .89436346-01 ZTA  .97328500 00 RHO  .36408822 05  XP -.52483804 05        VEHICLE IS NOT ECLIPSED
XMV  .10007543 06 YMV -.11310514 05 ZMV  .24540583 03  XM -.39127016 05 YM -.72473146 04  ZM -.20880368 04
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XSV  .83213432 05 YSV -.11924556 05 ZSV  .10337072 04  XS -.22265021 05 YS -.66332725 04  ZS -.28763371 04

17 OCTOBER       HR     MIN  - SEC TIME-START  .30816000 07  JULIAN DATE 3420.5000
LAT(DEG) -.24898236 01  LONG(DEG) .31123592 03   V.APO(FPS) .32540142 02  V.PERI(FPS) .39617999 03
ALT(NM)    .22469334 09  APO(NM)    .33211753 09   PERI(NM)    .27275227 08  PERIOD(MIN) .10070389 10
X  .26297178 01  Y -.89888436 00 Z   -.12003466 00    XD    .50419486-07    YD   -.11784700-06 ZD -.45168337-07
R  .27816932 01  A -.18871341 02 D   -.24731756 01     V    .13590518-06 BETA    .49814173 02 AZ   .24648653 03
A  .22246414 01  E   .84819867 00 I    .35026880 02 NODE  -.91599592 01     W   -.19194777 03   M   .45477161 01
R  .52683582-03  V   .20276734-03 G    .24782114-01     S    .26998829 03  SVE    .11759529 02   F   .19378958 03
ELK  .16358836 03 MLK  .17775423 03 SLK  .17518704 03  RM  .98695755 05 RS  .83059995 05          ELLIPSE
ETA  .89093566-01 ZTA  .76326783 00 RHO  .47522800 05  XP -.44923559 05            VEHICLE IS NOT ECLIPSED
XMV  .98464728 05 YMV -.61815655 04 ZMV  .27088130 04  XM -.36785066 05 YM -.14901641 05  ZM -.55242093 04
XSV  .82306431 05 YSV -.11057427 05 ZSV  .15322156 04  XS -.20626768 05 YS -.10025779 05  ZS -.43476119 04

27 OCTOBER       HR     MIN  - SEC TIME-START  .30960000 07  JULIAN DATE 3430.5000
LAT(DEG) -.31400696 01  LONG(DEG) .29994755 03   V.APO(FPS) .32589262 02  V.PERI(FPS) .39584553 03
ALT(NM)    .23158662 09  APO(NM)    .33183780 09   PERI(NM)    .27316458 08  PERIOD(MIN) .10060367 10
X  .26848864 01  Y -.99343481 00 Z   -.15599940 00    XD    .76753814-07    YD   -.10023244-06 ZD -.37743991-07
R  .28670304 01  A -.20304977 02 D   -.31190892 01     V    .13176607-06 BETA    .34446012 02 AZ   .24467666 03
A  .22231652 01  E   .84786826 00 I    .34995408 02 NODE  -.91621003 01     W   -.19192298 03   M   .45960600 01
R  .54299818-03  V   .20884452-03 G    .29813488-01     S    .26999125 03  SVE    .13923439 02   F   .19439520 03
ELK  .16201823 03 MLK  .17705469 03 SLK  .17581570 03  RM  .95680395 05 RS  .82006054 05          ELLIPSE
ETA  .88053227-01 ZTA  .56168587 00 RHO  .57166177 05  XP -.35677282 05            VEHICLE IS NOT ECLIPSED
XMV  .95534859 05 YMV -.14286338 04 ZMV  .50781714 04  XM -.32561225 05 YM -.21872241 05  ZM -.87371155 04
XSV  .81345859 05 YSV -.10184720 05 ZSV  .20286956 04  XS -.18372225 05 YS -.13116154 05  ZS -.56876398 04

 6 NOVEMBER      HR     MIN  - SEC TIME-START  .31104000 07  JULIAN DATE 3440.5000
LAT(DEG) -.35925887 01  LONG(DEG) .28920208 03   V.APO(FPS) .32626940 02  V.PERI(FPS) .39490128 03
ALT(NM)    .23969434 09  APO(NM)    .33215745 09   PERI(NM)    .27439855 08  PERIOD(MIN) .10078988 10
X  .27612952 01  Y -.10707985 01 Z   -.18470164 00    XD    .99434634-07    YD   -.78152409-07 ZD -.28395991-07
R  .29674021 01  A -.21195718 02 D   -.35685994 01     V    .12962013-06 BETA    .19082615 02 AZ   .24058645 03
A  .22259076 01  E   .84736942 00 I    .34999727 02 NODE  -.91615574 01     W   -.19199753 03   M   .46514311 01
R  .56200797-03  V   .21602419-03 G    .32492987-01     S    .26999448 03  SVE    .15535478 02   F   .19511635 03
ELK  .16102448 03 MLK  .17460505 03 SLK  .17646274 03  RM  .91766029 05 RS  .80905994 05          ELLIPSE
ETA  .86571672-01 ZTA  .36925383 00 RHO  .65060549 05  XP -.25025934 05            VEHICLE IS NOT ECLIPSED
XMV  .91443934 05 YMV  .26516013 04 ZMV  .72097084 04  XM -.26678141 05 YM -.27767030 05  ZM -.11541859 05
XSV  .80329706 05 YSV -.93028949 04 ZSV  .25247696 04  XS -.15563913 05 YS -.15812534 05  ZS -.68569207 04

16 NOVEMBER      HR     MIN  - SEC TIME-START  .31248000 07  JULIAN DATE 3450.5000
LAT(DEG) -.38383870 01  LONG(DEG) .27899797 03   V.APO(FPS) .32533524 02  V.PERI(FPS) .39639206 03
ALT(NM)    .24852438 09  APO(NM)    .33202597 09   PERI(NM)    .27247574 08  PERIOD(MIN) .10065379 10
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X   .28554083 01  Y -.11273716 01 Z   -.20458996 00   XD   .11760232-06   YD  -.52220769-07 ZD -.17391313-07
R   .30767158 01  A -.21545085 02 D   -.38127659 01    V   .12984519-06 BETA   .45586612 01 AZ  .21145042 03
A   .22239035 01  E  .84830224 00 I    .35023256 02 NODE  -.91592287 01    W  -.19192545 03  M  .47021471 01
R   .58271133-03  V  .22386649-03 G    .33126976-01    S   .26999774 03  SVE   .16591216 02  F  .19570682 03
ELK  .16060838 03 MLK   .17218938 03 SLK  .17712716 03  RM   .87090643 05 RS  .79756061 05        ELLIPSE
ETA  .84878571-01 ZTA   .18609135 00 RHO  .70987971 05  XP  -.13303644 05          VEHICLE IS NOT ECLIPSED
XMV  .86431650 05 YMV   .58117415 04 ZMV  .89762854 04  XM  -.19458448 05 YM -.32254084 05  ZM -.13774914 05
XSV  .79253385 05 YSV  -.84153433 04 ZSV  .30186840 04  XS  -.12280183 05 YS -.18027000 05  ZS -.78173129 04

26 NOVEMBER      HR     MIN   - SEC TIME-START   .31392000 07  JULIAN DATE 3460.5000
LAT(DEG) -.38800596 01   LONG(DEG) .26930580 03    V.APO(FPS) .32621905 02   V.PERI(FPS) .39537122 03
ALT(NM)    .25761388 09   APO(NM)    .33184785 09    PERI(NM)    .27377460 08   PERIOD(MIN) .10063353 10
X   .29630006 01  Y -.11601446 01 Z   -.21437158 00   XD   .13052710-06   YD  -.23198434-07 ZD -.50613089-08
R   .31892418 01  A -.21382519 02 D   -.38541619 01    V   .13266916-06 BETA   .11411032 02 AZ  .81922019 02
A   .22236050 01  E  .84755674 00 I    .34986974 02 NODE  -.91637927 01    W  -.19194414 03  M  .47519290 01
R   .60402306-03  V  .23201126-03 G    .32115505-01    S  -.89999088 02  SVE   .17120271 02  F  .19641296 03
ELK  .16074131 03 MLK   .17016341 03 SLK  .17781089 03  RM   .81840311 05 RS  .78559361 05        ELLIPSE
ETA  .83155885-01 ZTA   .11937211-01 RHO  .74801066 05  XP  -.88983513 03          VEHICLE IS NOT ECLIPSED
XMV  .80808538 05 YMV   .78813901 04 ZMV  .10281079 05  XM  -.11311772 05 YM -.35092419 05  ZM -.15309135 05
XSV  .78119594 05 YSV  -.75222351 04 ZSV  .35097648 04  XS  -.86228281 04 YS -.19688794 05  ZS -.85378202 04

 6 DECEMBER      HR     MIN   - SEC TIME-START   .31536000 07  JULIAN DATE 3470.5000
LAT(DEG) -.37269760 01   LONG(DEG) .26008051 03    V.APO(FPS) .32592451 02   V.PERI(FPS) .39528155 03
ALT(NM)    .26654654 09   APO(NM)    .33224022 09    PERI(NM)    .27391296 08   PERIOD(MIN) .10080426 10
X   .30792815 01  Y -.11668247 01 Z   -.21306575 00   XD   .13763332-06   YD   .80217150-08 ZD  .82054806-08
R   .32998260 01  A -.20753079 02 D   -.37020943 01    V   .13811086-06 BETA   .25100610 02 AZ  .73831020 02
A   .22261193 01  E  .84765398 00 I    .35012026 02 NODE  -.91599806 01    W  -.19199263 03  M  .48076189 01
R   .62496704-03  V  .24006874-03 G    .29849100-01    S  -.89996105 02  SVE   .17171432 02  F  .19716534 03
ELK  .16137802 03 MLK   .16872493 03 SLK  .17851786 03  RM   .76236457 05 RS  .77311479 05        ELLIPSE
ETA  .81535350-01 ZTA  -.15402310 00 RHO  .76430754 05  XP   .11834395 05          VEHICLE IS NOT ECLIPSED
XMV  .74916713 05 YMV   .87773093 04 ZMV  .11064978 05  XM  -.26925947 04 YM -.36145519 05  ZM -.16062405 05
XSV  .76923546 05 YSV  -.66211494 04 ZSV  .39991818 04  XS  -.46994277 04 YS -.20746560 05  ZS -.89966092 04

16 DECEMBER      HR     MIN   - SEC TIME-START   .31680000 07  JULIAN DATE 3480.5000
LAT(DEG) -.33917649 01   LONG(DEG) .25127076 03    V.APO(FPS) .32546162 02   V.PERI(FPS) .39635928 03
ALT(NM)    .27495936 09   APO(NM)    .33191263 09    PERI(NM)    .27251108 08   PERIOD(MIN) .10060765 10
X   .31990413 01  Y -.11459322 01 Z   -.20004543 00   XD   .13853272-06   YD   .40457750-07 ZD  .21981920-07
R   .34039748 01  A -.19708083 02 D   -.33691103 01    V   .14598407-06 BETA   .37844370 02 AZ  .71238409 02
A   .22232239 01  E  .84823619 00 I    .35014592 02 NODE  -.91597235 01    W  -.19191118 03  M  .48566554 01
R   .64469219-03  V  .24770796-03 G    .26664941-01    S  -.89993336 02  SVE   .16795244 02  F  .19781280 03
ELK  .16246662 03 MLK   .16806323 03 SLK  .17924683 03  RM   .70545789 05 RS  .76010739 05        ELLIPSE
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ETA   .80106115-01 ZTA -.31251495 00 RHO   .75883087 05  XP   .24468234 05             VEHICLE IS NOT ECLIPSED
XMV   .69113225 05 YMV   .85012544 04 ZMV   .11304840 05  XM   .59198428 04 YM -.35378934 05  ZM -.15996878 05
XSV   .75662700 05 YSV -.57165142 04 ZSV   .44843994 04  XS -.62963281 03 YS -.21161165 05  ZS -.91764369 04

26 DECEMBER      HR    MIN  - SEC TIME-START  .31824000 07  JULIAN DATE 3490.5000
LAT(DEG) -.28880766 01  LONG(DEG) .24281429 03   V.APO(FPS) .32639356 02  V.PERI(FPS) .39499886 03
ALT(NM)    .28254382 09  APO(NM)    .33194569 09   PERI(NM)    .27426017 08  PERIOD(MIN) .10069505 10
X   .33168260 01  Y -.10968604 01 Z  -.17506354 00   XD    .13305043-06   YD   .73071807-07 ZD  .35815949-07
R   .34978686 01  A -.18298833 02 D  -.28687739 01    V    .15596374-06 BETA   .49419131 02 AZ  .69777534 02
A   .22245111 01  E   .84735061 00 I   .34985644 02 NODE -.91651887 01     W  -.19197373 03  M  .49084923 01
R  .66247511-03  V   .25463036-03 G   .22828823-01   S  -.89990786 02  SVE   .16048207 02  F  .19863526 03
ELK  .16395502 03 MLK   .16835069 03 SLK   .17998021 03  RM   .65084600 05 RS  .74658930 05          ELLIPSE
ETA   .78925240-01 ZTA -.46415732 00 RHO   .73247619 05  XP   .36613371 05             VEHICLE IS NOT ECLIPSED
XMV   .63745342 05 YMV   .71465266 04 ZMV   .11021055 05  XM   .14050347 05 YM -.32873234 05  ZM -.15127146 05
XSV   .74338384 05 YSV -.48063879 04 ZSV   .49658104 04  XS   .34573057 04 YS -.20920320 05  ZS -.90719014 04

 5 JANUARY       HR    MIN  - SEC TIME-START  .31968000 07  JULIAN DATE 3500.5000
LAT(DEG) -.22294365 01  LONG(DEG) .23468531 03   V.APO(FPS) .32560224 02  V.PERI(FPS) .39572567 03
ALT(NM)    .28904429 09  APO(NM)    .33224923 09   PERI(NM)    .27334235 08  PERIOD(MIN) .10078406 10
X   .34271254 01  Y -.10199169 01 Z  -.13827127 00   XD    .12123189-06   YD   .10480212-06 ZD  .49245275-07
R   .35783429 01  A -.16573072 02 D  -.22145258 01    V    .16764771-06 BETA   .59798224 02 AZ  .68737580 02
A   .22258219 01  E   .84795099 00 I   .35021076 02 NODE -.91575208 01     W  -.19197278 03  M  .49630244 01
R  .67771645-03  V   .26059178-03 G   .18541140-01   S  -.89988446 02  SVE   .14982609 02  F  .19941306 03
ELK  .16579447 03 MLK   .16969906 03 SLK   .17921216 03  RM   .60198448 05 RS  .73250092 05          ELLIPSE
ETA   .78027502-01 ZTA -.60978389 00 RHO   .68680969 05  XP   .47919384 05             VEHICLE IS NOT ECLIPSED
XMV   .59113826 05 YMV   .48873354 04 ZMV   .10272426 05  XM   .21268920 05 YM -.28809344 05  ZM -.13515559 05
XSV   .72943870 05 YSV -.38906038 04 ZSV   .54434345 04  XS   .74388760 04 YS -.20031405 05  ZS -.86865676 04

15 JANUARY       HR    MIN  - SEC TIME-START  .32112000 07  JULIAN DATE 3510.5000
LAT(DEG) -.14286147 01  LONG(DEG) .22683054 03   V.APO(FPS) .32572341 02  V.PERI(FPS) .39612774 03
ALT(NM)    .29425452 09  APO(NM)    .33180473 09   PERI(NM)    .27280102 08  PERIOD(MIN) .10057450 10
X   .35245631 01  Y -.91631390 00 Z  -.90213722-01   XD    .10333817-06   YD   .13462002-06 ZD  .61821560-07
R   .36428443 01  A -.14573112 02 D  -.14190544 01    V    .18061903-06 BETA   .69046978 02 AZ  .67907044 02
A   .22227355 01  E   .84804135 00 I   .35004657 02 NODE -.91615989 01     W  -.19190898 03  M  .50114815 01
R  .68993262-03  V   .26538126-03 G   .13943322-01   S  -.89986302 02  SVE   .13642702 02  F  .20016713 03
ELK  .16794134 03 MLK   .17205555 03 SLK   .17839775 03  RM   .56249122 05 RS  .71784601 05          ELLIPSE
ETA   .77433630-01 ZTA -.74992607 00 RHO   .62412415 05  XP   .58061726 05             VEHICLE IS NOT ECLIPSED
XMV   .55465344 05 YMV   .19610745 04 ZMV   .91495118 04  XM   .27202790 05 YM -.23453089 05  ZM -.11265462 05
XSV   .71478711 05 YSV -.29732100 04 ZSV   .59146436 04  XS   .11189423 05 YS -.18518804 05  ZS -.80305939 04

25 JANUARY       HR    MIN  - SEC TIME-START  .32256000 07  JULIAN DATE 3520.5000
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LAT(DEG) -.49735379 00  LONG(DEG) .21921393 03   V.APO(FPS) .32633079 02  V.PERI(FPS) .39487367 03
ALT(NM)   .29801369 09   APO(NM)   .33211165 09   PERI(NM)    .27443151 08  PERIOD(MIN) .10077201 10
X  .36040795 01   Y -.78812247 00 Z   -.31810748-01    XD    .79841300-07     YD     .16156941-06 ZD  .73127325-07
R  .36893818 01   A -.12334992 02 D   -.49402428 00     V    .19449142-06 BETA    .77272140 02 AZ  .67205550 02
A  .22256445 01   E   .84733304 00 I    .34992868 02 NODE  -.91645695 01     W  -.19199993 03   M  .50653028 01
R  .69874655-03   V   .26882397-03 G    .91321675-02     S  -.89984335 02  SVE    .12074078 02   F  .20111104 03
ELK  .17035770 03 MLK  .17494293 03 SLK  .17754732 03   RM   .53551452 05 RS  .70261800 05          ELLIPSE
ETA  .77156229-01 ZTA -.88494775 00 RHO  .54735324 05   XP   .66767811 05          VEHICLE IS NOT ECLIPSED
XMV  .52967259 05 YMV -.13370876 04 ZMV  .77742989 04   XM   .31565922 05 YM -.17148215 05  ZM -.85204155 04
XSV  .69941428 05 YSV -.20511821 04 ZSV  .63804378 04   XS   .14591754 05 YS -.16434120 05  ZS -.71265544 04

 4 FEBRUARY      HR    MIN  - SEC TIME-START  .32400000 07  JULIAN DATE 3530.5000
LAT(DEG)  .55371911 00   LONG(DEG) .21180585 03   V.APO(FPS) .32543965 02  V.PERI(FPS) .39605852 03
ALT(NM)   .30020284 09   APO(NM)   .33216966 09   PERI(NM)    .27291084 08  PERIOD(MIN) .10073247 10
X  .36611035 01   Y -.63819633 00 Z    .35675927-01    XD    .51400930-07     YD     .18479425-06 ZD  .82788461-07
R  .37164830 01   A -.98883276 01 D    .55001230 00     V    .20891361-06 BETA    .84590012 02 AZ  .66599047 02
A  .22250623 01   E   .84813917 00 I    .35021698 02 NODE  -.91562066 01     W  -.19194570 03   M  .51178272 01
R  .70387936-03   V   .27080686-03 G    .41672926-02     S  -.89982522 02  SVE    .10313816 02   F  .20193919 03
ELK  .17301089 03 MLK  .17657808 03 SLK  .17665809 03   RM   .52281179 05 RS  .68675316 05          ELLIPSE
ETA  .77204024-01 ZTA -.10153980 01 RHO  .45971883 05   XP   .73846539 05          VEHICLE IS NOT ECLIPSED
XMV  .51689859 05 YMV -.46874094 04 ZMV  .62855650 04   XM   .34180811 05 YM -.10281396 05  ZM -.54487911 04
XSV  .68324609 05 YSV -.11268384 04 ZSV  .68393840 04   XS   .17546061 05 YS -.13841967 05  ZS -.60026100 04

14 FEBRUARY      HR    MIN  - SEC TIME-START  .32544000 07  JULIAN DATE 3540.5000
LAT(DEG)  .17150449 01   LONG(DEG) .20458286 03   V.APO(FPS) .32602964 02  V.PERI(FPS) .39577893 03
ALT(NM)   .30074217 09   APO(NM)   .33173930 09   PERI(NM)    .27324430 08  PERIOD(MIN) .10056564 10
X  .36917065 01   Y -.47007576 00 Z    .11068404 00    XD    .18825184-07     YD     .20358294-06 ZD  .90492596-07
R  .37231598 01   A -.72565881 01 D    .17035699 01     V    .22358290-06 BETA    .91114156 02 AZ  .66072996 02
A  .22226048 01   E   .84778552 00 I    .34996247 02 NODE  -.91644622 01     W  -.19192078 03   M  .51667995 01
R  .70514390-03   V   .27114947-03 G   -.91871296-03     S  -.89930843 02  SVE    .83964487 01   F  .20285153 03
ELK  .17587047 03 MLK  .17494566 03 SLK  .17572762 03   RM   .52417029 05 RS  .67026643 05          ELLIPSE
ETA  .77584637-01 ZTA -.11415160 01 RHO  .36494497 05   XP   .79163838 05          VEHICLE IS NOT ECLIPSED
XMV  .51613313 05 YMV -.77637896 04 ZMV  .48305745 04   XM   .34975146 05 YM -.32617717 04  ZM -.22344958 04
XSV  .66628789 05 YSV -.20278271 03 ZSV  .72893336 04   XS   .19959671 05 YS -.10822779 05  ZS -.46932549 04

24 FEBRUARY      HR    MIN  - SEC TIME-START  .32688000 07  JULIAN DATE 3550.5000
LAT(DEG)  .29782445 01   LONG(DEG) .19752759 03   V.APO(FPS) .32605830 02  V.PERI(FPS) .39503329 03
ALT(NM)   .29958642 09   APO(NM)   .33228630 09   PERI(NM)    .27423569 08  PERIOD(MIN) .10083721 10
X  .36927078 01   Y -.28784158 00 Z    .19141332 00    XD   -.16961592-07     YD     .21738874-06 ZD  .95998255-07
R  .37088519 01   A -.44571160 01 D    .29583413 01     V    .23824614-06 BETA    .96944225 02 AZ  .65622238 02
A  .22266043 01   E   .84750773 00 I    .35003299 02 NODE  -.91617690 01     W  -.19201003 03   M  .52218249 01
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R  .70243407-03   V  .26987792-03 G  -.61153823-02    S  -.89979275 02  SVE   .63655501 01  F  .20391903 03
ELK  .17885944 03 MLK  .17269304 03 SLK  .17474717 03  RM  .53721454 05 RS  .65312071 05          ELLIPSE
ETA  .78306836-01 ZTA -.12634218 01 RHO  .26721335 05  XP  .82659376 05          VEHICLE IS NOT ECLIPSED
XMV  .52613870 05 YMV -.10252713 05 ZMV  .35577097 04  XM  .33998075 05 YM  .35014284 04  ZM  .93186298 03
XSV  .64848848 05 YSV  .72364831 03 ZSV  .77311050 04  XS  .21763097 05 YS -.74749324 04  ZS -.32415323 04

 5 MARCH        HR    MIN  - SEC TIME-START  .32832000 07  JULIAN DATE 3560.5000
LAT(DEG)  .43361160 01  LONG(DEG) .19062861 03   V.APO(FPS) .32548305 02  V.PERI(FPS) .39619369 03
ALT(NM)   .29672232 09  APO(NM)   .33201729 09   PERI(NM)   .27272893 08  PERIOD(MIN) .10066079 10
X  .36617628 01  Y -.95973502-01 Z   .27588657 00   XD  -.54955870-07   YD   .22583587-06 ZD  .99137523-07
R  .36733950 01  A -.15013583 01 D   .43071964 01   V   .25268604-06 BETA   .10216236 03 AZ  .65246695 02
A  .22240066 01  E  .84816833 00 I   .35017112 02 NODE -.91566535 01    W  -.19192109 03  M  .52723901 01
R  .69571875-03  V  .26688735-03 G  -.11428772-01    S  -.89977795 02  SVE   .42845955 01  F  .20485930 03
ELK  .17774874 03 MLK  .17132886 03 SLK  .17371378 03  RM  .55817876 05 RS  .63526016 05          ELLIPSE
ETA  .79381953-01 ZTA -.13814417 01 RHO  .17157092 05  XP  .84352478 05          VEHICLE IS NOT ECLIPSED
XMV  .54474876 05 YMV -.11889973 05 ZMV  .25984159 04  XM  .31411259 05 YM  .96389277 04  ZM  .38724649 04
XSV  .62977978 05 YSV  .16477943 04 ZSV  .81617301 04  XS  .22908157 05 YS -.38988394 04  ZS -.16908493 04

15 MARCH        HR    MIN  - SEC TIME-START  .32976000 07  JULIAN DATE 3570.5000
LAT(DEG)  .57826616 01  LONG(DEG) .18386929 03   V.APO(FPS) .32626964 02  V.PERI(FPS) .39540266 03
ALT(NM)   .29216519 09  APO(NM)   .33176810 09   PERI(NM)   .27372948 08  PERIOD(MIN) .10059812 10
X  .35974047 01  Y  .10080112 00 Z   .36201429 00   XD  -.94129444-07   YD   .22872851-06 ZD  .99819082-07
R  .36169788 01  A  .16050371 01 D   .57442077 01   V   .26672257-06 BETA   .10683673 03 AZ  .64949415 02
A  .22230834 01  E  .84754810 00 I   .34991152 02 NODE -.91674962 01    W  -.19194687 03  M  .53227195 01
R  .68503386-03  V  .26219662-03 G  -.16881780-01    S  -.89976377 02  SVE   .23908958 01  F  .20598762 03
ELK  .17436931 03 MLK  .17117162 03 SLK  .17262011 03  RM  .58295957 05 RS  .61669324 05          ELLIPSE
ETA  .80825048-01 ZTA -.14955940 01 RHO  .89486714 04  XP  .84319785 05          VEHICLE IS NOT ECLIPSED
XMV  .56909012 05 YMV -.12471260 05 ZMV  .20617454 04  XM  .27467613 05 YM  .14835536 05  ZM  .64292491 04
XSV  .61015513 05 YSV  .25690028 04 ZSV  .85797970 04  XS  .23361112 05 YS -.20472562 03  ZS -.88802490 02

25 MARCH        HR    MIN  - SEC TIME-START  .33120000 07  JULIAN DATE 3580.5000
LAT(DEG)  .73131562 01  LONG(DEG) .17728292 03   V.APO(FPS) .32573268 02  V.PERI(FPS) .39535923 03
ALT(NM)   .28595646 09  APO(NM)   .33239044 09   PERI(NM)   .27382170 08  PERIOD(MIN) .10086359 10
X  .34990597 01  Y  .29766344 00 Z   .44766131 00   XD  -.13346231-06   YD   .22605070-06 ZD  .98028601-07
R  .35401162 01  A  .48624194 01 D   .72647210 01   V   .28021547-06 BETA   .11101996 03 AZ  .64736006 02
A  .22269927 01  E  .84776445 00 I   .35012634 02 NODE -.91575946 01    W  -.19200007 03  M  .53776772 01
R  .67047654-03  V  .25584054-03 G  -.22509596-01    S  -.89974997 02  SVE   .20148477 01  F  .20719797 03
ELK  .17080391 03 MLK  .17220428 03 SLK  .17145486 03  RM  .60770632 05 RS  .59735278 05          ELLIPSE
ETA  .82655656-01 ZTA  .46773693 01 RHO  .70565275 04  XP  .82698715 05          VEHICLE IS NOT ECLIPSED
XMV  .59565192 05 YMV -.11672618 05 ZMV  .20245079 04  XM  .22504763 05 YM  .18854272 05  ZM  .84753254 04
XSV  .58952598 05 YSV  .34879204 04 ZSV  .89849366 04  XS  .23117357 05 YS  .34937339 04  ZS  .15148967 04
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 4 APRIL        HR    MIN  - SEC TIME-START  .33264000 07  JULIAN DATE 3590.5000
LAT(DEG)  .89242545 01  LONG(DEG) .17083241 03   V.APO(FPS) .32568716 02  V.PERI(FPS) .39614924 03
ALT(NM)   .27816073 09  APO(NM)    .33182783 09   PERI(NM)    .27277483 08  PERIOD(MIN) .10058311 10
X  .33670193 01  Y  .48985306 00 Z   .53071077 00   XD  -.17197249-06   YD   .21794835-06 ZD  .93820218-07
R  .34436069 01  A  .82776390 01 D   .88654605 01    V   .29304992-06 BETA   .11474941 03 AZ  .64614935 02
A  .22228622 01  E  .84806461 00 I   .35009678 02 NODE  -.91592518 01    W  -.19190505 03   M  .54270729 01
R  .65219827-03  V  .24788494-03 G  -.28359296-01    S  -.89973626 02  SVE   .38299645 01   F  .20834715 03
ELK  .16706931 03 MLK  .17428970 03 SLK  .17021202 03  RM  .62928377 05 RS  .57719403 05          ELLIPSE
ETA  .84898735-01 ZTA  .45709469 01 RHO  .12880347 05  XP  .79674728 05            VEHICLE IS NOT ECLIPSED
XMV  .62066315 05 YMV -.10070033 05 ZMV  .25194647 04  XM  .16906651 05 YM  .21559467 05  ZM  .99282822 04
XSV  .56783193 05 YSV  .43985026 04 ZSV  .93729268 04  XS  .22189773 05 YS  .70909324 04  ZS  .30748202 04

14 APRIL        HR    MIN  - SEC TIME-START  .33408000 07  JULIAN DATE 3600.5000
LAT(DEG)  .10614037 02  LONG(DEG) .16456491 03   V.APO(FPS) .32631421 02  V.PERI(FPS) .39514910 03
ALT(NM)   .26886360 09  APO(NM)    .33191594 09   PERI(NM)    .27406466 08  PERIOD(MIN) .10067433 10
X  .32023895 01  Y  .67279891 00 Z   .60911895 00   XD  -.20876029-06   YD   .20471158-06 ZD  .87308139-07
R  .33285106 01  A  .11864870 02 D   .10544577 02    V   .30513996-06 BETA   .11805091 03 AZ  .64598068 02
A  .22242060 01  E  .84743849 00 I   .34992677 02 NODE  -.91682244 01    W  -.19197910 03   M  .54790810 01
R  .63039973-03  V  .23839542-03 G  -.34490913-01    S  -.89972233 02  SVE   .62242702 01   F  .20976379 03
ELK  .16316064 03 MLK  .17727110 03 SLK  .16887678 03  RM  .64531411 05 RS  .55620310 05          ELLIPSE
ETA  .87585169-01 ZTA  .44685329 01 RHO  .19628396 05  XP  .75469592 05            VEHICLE IS NOT ECLIPSED
XMV  .64038589 05 YMV -.71303092 04 ZMV  .35384769 04  XM  .11073009 05 YM  .22910714 05  ZM  .10748323 05
XSV  .54503210 05 YSV  .53011117 04 ZSV  .97425475 04  XS  .20608388 05 YS  .10479293 05  ZS  .45442523 04

24 APRIL        HR    MIN  - SEC TIME-START  .33552000 07  JULIAN DATE 3610.5000
LAT(DEG)  .12382073 02  LONG(DEG) .15849237 03   V.APO(FPS) .32551975 02  V.PERI(FPS) .39568340 03
ALT(NM)   .25816936 09  APO(NM)    .33237261 09   PERI(NM)    .27340380 08  PERIOD(MIN) .10083852 10
X  .30070088 01  Y  .84223547 00 Z   .68096359 00   XD  -.24302831-06   YD   .18675844-06 ZD  .78659549-07
R  .31961185 01  A  .15647070 02 D   .12301710 02    V   .31643135-06 BETA   .12093687 03 AZ  .64702054 02
A  .22266237 01  E  .84797157 00 I   .35016309 02 NODE  -.91544589 01    W  -.19197490 03   M  .55328742 01
R  .60532547-03  V  .22746799-03 G  -.40975688-01    S  -.89970784 02  SVE   .88012962 01   F  .21119241 03
ELK  .15906374 03 MLK  .17894296 03 SLK  .16743270 03  RM  .65404760 05 RS  .53428376 05          ELLIPSE
ETA  .90752412-01 ZTA  .43704313 01 RHO  .25611692 05  XP  .70333436 05            VEHICLE IS NOT ECLIPSED
XMV  .65131838 05 YMV -.32161714 04 ZMV  .50281770 04  XM  .53971318 04 YM  .22970686 05  ZM  .10943729 05
XSV  .52099986 05 YSV  .61928737 04 ZSV  .10091143 05  XS  .18428983 05 YS  .13561641 05  ZS  .58807632 04

 4 MAY          HR    MIN  - SEC TIME-START  .33696000 07  JULIAN DATE 3620.5000
LAT(DEG)  .14229432 02  LONG(DEG) .15264898 03   V.APO(FPS) .32598299 02  V.PERI(FPS) .39596759 03
ALT(NM)   .24620071 09  APO(NM)    .33164433 09   PERI(NM)    .27299683 08  PERIOD(MIN) .10051534 10
X  .27833589 01  Y  .99430815 00 Z   .74448673 00   XD  -.27409560-06   YD   .16461155-06 ZD  .68082731-07
R  .30479494 01  A  .19658413 02 D   .14138001 02    V   .32689542-06 BETA   .12340466 03 AZ  .64950786 02
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A   .22218638 01   E   .84787264 00 I    .35002269 02 NODE  -.91635327 01     W   -.19190220 03   M -.70108500 00
R   .57726313-03   V   .21530123-03 G   -.47899995-01     S   -.89969248 02  SVE    .11499829 02   F  .21269498 03
ELK  .15475485 03 MLK   .17457933 03 SLK  .16586486 03  RM   .65442168 05 RS   .51139528 05             ELLIPSE
ETA  .94444129-01 ZTA   .42768334 01 RHO  .30474085 05  XP   .64525841 05              VEHICLE IS NOT ECLIPSED
XMV  .65062553 05 YMV   .14259456 04 ZMV  .68926337 04  XM   .22074023 03 YM   .21895413 05   ZM  .10569198 05
XSV  .49566852 05 YSV   .70669821 04 ZSV  .10413280 05  XS   .15716441 05 YS   .16254377 05   ZS  .70485515 04

14 MAY          HR     MIN  - SEC TIME-START  .33840000 07  JULIAN DATE 3630.5000
LAT(DEG)   .16158436 02  LONG(DEG) .14708368 03   V.APO(FPS) .32612175 02  V.PERI(FPS) .39509729 03
ALT(NM)     .23309817 09  APO(NM)    .33216700 09   PERI(NM)    .27414615 08  PERIOD(MIN) .10078328 10
X   .25344494 01   Y   .11256465 01 Z    .79812222 00    XD  -.30142441-06     YD    .13886460-06 ZD  .55811417-07
R   .28857430 01   A   .23947848 02 D    .16055850 02     V    .33653375-06 BETA   .12543759 03 AZ  .65378246 02
A   .22258105 01   E   .84750314 00 I    .34998709 02 NODE  -.91657348 01     W   -.19200581 03   M -.64765292 00
R   .54654223-03   V   .20197416-03 G   -.55353559-01     S   -.89967592 02  SVE    .14306604 02   F  .21452057 03
ELK  .15019842 03 MLK   .16963120 03 SLK  .16414468 03  RM   .64589099 05 RS   .48748227 05             ELLIPSE
ETA  .98709127-01 ZTA   .41883834 01 RHO  .34082668 05  XP   .58317630 05              VEHICLE IS NOT ECLIPSED
XMV  .63627310 05 YMV   .64959268 04 ZMV  .90066724 04  XM  -.41821543 04 YM   .19905955 05   ZM  .97131726 04
XSV  .46893429 05 YSV   .79226106 04 ZSV  .10706457 05  XS   .12551727 05 YS   .18479271 05   ZS  .80133882 04

24 MAY          HR     MIN  - SEC TIME-START  .33984000 07  JULIAN DATE 3640.5000
LAT(DEG)   .18172034 02  LONG(DEG) .14186576 03   V.APO(FPS) .32550803 02  V.PERI(FPS) .39589105 03
ALT(NM)     .21902067 09  APO(NM)    .33222440 09   PERI(NM)    .27312867 08  PERIOD(MIN) .10076464 10
X   .22636864 01   Y   .12334159 01 Z    .84051283 00    XD  -.32463164-06     YD    .11016296-06 ZD  .42094425-07
R   .27114669 01   A   .28584661 02 D    .18058299 02     V    .34538893-06 BETA   .12700003 03 AZ  .66033404 02
A   .22255360 01   E   .84805031 00 I    .35014639 02 NODE  -.91538688 01     W   -.19194424 03   M -.59547296 00
R   .51353539-03   V   .18774490-03 G   -.63439486-01     S   -.89965802 02  SVE    .17234433 02   F  .21635200 03
ELK  .14534339 03 MLK   .16416881 03 SLK  .16224195 03  RM   .62833175 05 RS   .46242140 05             ELLIPSE
ETA  .10359825 00 ZTA   .41059457 01 RHO  .36404776 05  XP   .51976295 05              VEHICLE IS NOT ECLIPSED
XMV  .60715426 05 YMV   .11652039 05 ZMV  .11219403 05  XM  -.76209775 04 YM   .17277558 05   ZM  .84947074 04
XSV  .44062797 05 YSV   .87516650 04 ZSV  .10964203 05  XS   .90316509 04 YS   .20177932 05   ZS  .87499075 04

 3 JUNE         HR     MIN  - SEC TIME-START  .34128000 07  JULIAN DATE 3650.5000
LAT(DEG)   .20272228 02  LONG(DEG) .13708250 03   V.APO(FPS) .32625799 02  V.PERI(FPS) .39572365 03
ALT(NM)     .20414899 09  APO(NM)    .33153222 09   PERI(NM)    .27330317 08  PERIOD(MIN) .10048113 10
X   .19747393 01   Y   .13153510 01 Z    .87051699 00    XD  -.34349342-06     YD    .79176869-07 ZD  .27180054-07
R   .25273590 01   A   .33667123 02 D    .20147456 02     V    .35354697-06 BETA   .12803139 03 AZ  .66987559 02
A   .22213595 01   E   .84766737 00 I    .34998232 02 NODE  -.91675368 01     W   -.19191549 03   M -.54557073 00
R   .47866648-03   V   .17277193-03 G   -.72238470-01     S   -.89963894 02  SVE    .20312480 02   F  .21845827 03
ELK  .14011747 03 MLK   .15821076 03 SLK  .16011813 03  RM   .60210253 05 RS   .43615317 05             ELLIPSE
ETA  .10915631 00 ZTA   .40305196 01 RHO  .37481230 05  XP   .45749940 05              VEHICLE IS NOT ECLIPSED
XMV  .56327589 05 YMV   .16545387 05 ZMV  .13368900 05  XM  -.10010354 05 YM   .14305987 05   ZM  .70489541 04
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XSV  .41063609 05 YSV  .95453806 04 ZSV  .11178626 05  XS  .52536260 04 YS  .21305993 05  ZS  .92392284 04

13 JUNE          HR    MIN  - SEC TIME-START  .34272000 07  JULIAN DATE 3660.5000
LAT(DEG)  .22456401 02  LONG(DEG) .13290734 03   V.APO(FPS) .32577276 02  V.PERI(FPS) .39522558 03
ALT(NM)   .18869230 09  APO(NM)    .33245026 09   PERI(NM)    .27399732 08  PERIOD(MIN) .10089613 10
X  .16713961 01  Y  .13697625 01 Z   .88719973 00  XD  -.35796544-06   YD   .46556222-07 ZD  .11291898-07
R  .23360088 01  A  .39335712 02 D   .22320859 02   V   .36115681-06 BETA  .12844090 03 AZ  .68344125 02
A  .22274717 01  E  .84769959 00 I   .35004701 02 NODE -.91613071 01    W  -.19201614 03  M -.49152291 00
R  .44242591-03  V  .15731808-03 G  -.81776477-01   S  -.89961979 02  SVE  .23578396 02  F  .22096065 03
ELK  .13441856 03 MLK  .15173069 03 SLK  .15771131 03  RM  .56787756 05 RS  .40855873 05       ELLIPSE
ETA  .11540416 00 ZTA  .39639007 01 RHO  .37385721 05  XP  .39879163 05       VEHICLE IS NOT ECLIPSED
XMV  .50558120 05 YMV  .20850196 05 ZMV  .15296901 05  XM -.11355759 05 YM  .11277391 05  ZM  .55122446 04
XSV  .37875087 05 YSV  .10297003 05 ZSV  .11342484 05  XS  .13272739 04 YS  .21830584 05  ZS  .94666611 04

23 JUNE          HR    MIN  - SEC TIME-START  .34416000 07  JULIAN DATE 3670.5000
LAT(DEG)  .24709195 02  LONG(DEG) .12949891 03   V.APO(FPS) .32570378 02  V.PERI(FPS) .39593658 03
ALT(NM)   .17289880 09  APO(NM)    .33197429 09   PERI(NM)    .27305576 08  PERIOD(MIN) .10065645 10
X  .13573968 01  Y  .13955011 01 Z   .88979983 00  XD  -.36820276-06   YD   .12895474-07 ZD -.53957094-08
R  .21404890 01  A  .45793008 02 D   .24563363 02   V   .36846801-06 BETA  .12809496 03 AZ  .70253493 02
A  .22239426 01  E  .84798203 00 I   .35010276 02 NODE -.91559893 01    W  -.19191905 03  M -.44062483 00
R  .40539564-03  V  .14168571-03 G  -.91928014-01   S  -.89960381 02  SVE  .27099850 02  F  .22362390 03
ELK  .12810228 03 MLK  .14465930 03 SLK  .15494661 03  RM  .52662709 05 RS  .37947453 05       ELLIPSE
ETA  .12230121 00 ZTA  .39085678 01 RHO  .36235245 05  XP  .34579959 05       VEHICLE IS NOT ECLIPSED
XMV  .43589024 05 YMV  .24275980 05 ZMV  .16853331 05  XM -.11751471 05 YM  .84553022 04  ZM  .40168000 04
XSV  .34472250 05 YSV  .10989022 05 ZSV  .11441788 05  XS -.26346973 04 YS  .21742260 05  ZS  .94283423 04

3 JULY           HR    MIN  - SEC TIME-START  .34560000 07  JULIAN DATE 3680.5000
LAT(DEG)  .26984808 02  LONG(DEG) .12718358 03   V.APO(FPS) .32639061 02  V.PERI(FPS) .39552334 03
ALT(NM)   .15707578 09  APO(NM)    .33154228 09   PERI(NM)    .27356108 08  PERIOD(MIN) .10049618 10
X  .10362562 01  Y  .13918870 01 Z   .87767147 00  XD  -.37457610-06   YD  -.21325395-07 ZD -.22798388-07
R  .19446037 01  A  .53332413 02 D   .26829492 02   V   .37587469-06 BETA  .12680060 03 AZ  .72932680 02
A  .22215814 01  E  .84753887 00 I   .34997843 02 NODE -.91700921 01    W  -.19193990 03  M -.38965094 00
R  .36829615-03  V  .12624423-03 G  -.10218350 00   S  -.89959910 02  SVE  .30966342 02  F  .22689250 03
ELK  .12096381 03 MLK  .13685629 03 SLK  .15171041 03  RM  .47969409 05 RS  .34878157 05       ELLIPSE
ETA  .12966601 00 ZTA  .38678780 01 RHO  .34183845 05  XP  .30035454 05       VEHICLE IS NOT ECLIPSED
XMV  .35676318 05 YMV  .26598030 05 ZMV  .17911153 05  XM -.11371074 05 YM  .60484849 04  ZM  .26745090 04
XSV  .30830270 05 YSV  .11603442 05 ZSV  .11460386 05  XS -.65250254 04 YS  .21043072 05  ZS  .91252756 04

13 JULY          HR    MIN  - SEC TIME-START  .34704000 07  JULIAN DATE 3690.5000
LAT(DEG)  .29169222 02  LONG(DEG) .12636912 03   V.APO(FPS) .32541965 02  V.PERI(FPS) .39542652 03
ALT(NM)   .14162407 09  APO(NM)    .33268220 09   PERI(NM)    .27375207 08  PERIOD(MIN) .10098338 10
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X  .71106539 00  Y  .13585652 01 Z   .85017711 00   XD  -.37770705-06   YD  -.55857691-07 ZD -.40998704-07
R  .17533152 01  A  .62372691 02 D   .29005717 02   V    .38400988-06 BETA  .12428972 03 AZ  .76684652 02
A  .22287556 01  E  .84792355 00 I   .35008020 02 NODE  -.91566040 01    W  -.19200827 03  M -.33590788 00
R  .33206728-03  V  .11150873-03 G  -.11116173 00    S  -.89962454 02  SVE  .35287073 02  F  .23083648 03
ELK  .11271427 03 MLK  .12806959 03 SLK  .14782375 03  RM  .42869266 05 RS  .31626412 05          ELLIPSE
ETA  .13701284 00 ZTA  .38469729 01 RHO  .31397325 05  XP  .26411638 05          VEHICLE IS NOT ECLIPSED
XMV  .27111157 05 YMV  .27663947 05 ZMV  .18370225 05  XM -.10433218 05 YM  .42010085 04  ZM  .15705605 04
XSV  .26908538 05 YSV  .12113992 05 ZSV  .11375929 05  XS -.10230598 05 YS  .19750963 05  ZS  .85648566 04

23 JULY        HR     MIN  - SEC TIME-START  .34848000 07  JULIAN DATE 3700.5000
LAT(DEG)  .31004575 02  LONG(DEG) .12761800 03   V.APO(FPS) .32606275 02  V.PERI(FPS) .39584319 03
ALT(NM)   .12709412 09   APO(NM)   .33165330 09   PERI(NM)    .27315684 08  PERIOD(MIN) .10052584 10
X  .38424852 00  Y  .12952342 01 Z   .80649118 00   XD  -.37852786-06   YD  -.90873173-07 ZD -.60382606-07
R  .15734379 01  A  .73476306 02 D   .30834918 02   V    .39393824-06 BETA  .12020623 03 AZ  .81896671 02
A  .22220184 01  E  .84779407 00 I   .35006136 02 NODE  -.91599506 01    W  -.19190702 03  M -.28550211 00
R  .29799960-03  V  .98172793-04 G  -.11566128 00    S  -.89971993 02  SVE  .40188870 02  F  .23554565 03
ELK  .10295646 03 MLK  .11788341 03 SLK  .14301608 03  RM  .37565119 05 RS  .28168315 05          ELLIPSE
ETA  .14322952 00 ZTA  .38528213 01 RHO  .28056290 05  XP  .23843461 05          VEHICLE IS NOT ECLIPSED
XMV  .18203803 05 YMV  .27389534 05 ZMV  .18154151 05  XM -.91913076 04 YM  .29900041 04  ZM  .76198706 03
XSV  .22660350 05 YSV  .12474188 05 ZSV  .11151554 05  XS -.13647854 05 YS  .17905351 05  ZS  .77645836 04

 2 AUGUST      HR     MIN  - SEC TIME-START  .34992000 07  JULIAN DATE 3710.5000
LAT(DEG)  .31960571 02  LONG(DEG) .13155716 03   V.APO(FPS) .32629545 02  V.PERI(FPS) .39542223 03
ALT(NM)   .11427068 09   APO(NM)   .33172468 09   PERI(NM)    .27370176 08  PERIOD(MIN) .10057871 10
X  .57269736-01  Y  .12011237 01 Z   .74522515 00   XD  -.37832126-06   YD  -.12738410-06 ZD -.81932056-07
R  .14146867 01  A  .87270195 02 D   .31787982 02   V    .40751263-06 BETA  .11413535 03 AZ  .88940593 02
A  .22227975 01  E  .84754393 00 I   .35001130 02 NODE  -.91686889 01    W  -.19197151 03  M -.23355377 00
R  .26793308-03  V  .87315154-04 G  -.10934196 00    S  -.89995486 02  SVE  .45702210 02  F  .24182555 03
ELK  .91182608 02 MLK  .10559946 03 SLK  .13680782 03  RM  .32332928 05 RS  .24482020 05          ELLIPSE
ETA  .14601151 00 ZTA  .38941171 01 RHO  .24339487 05  XP  .22437541 05          VEHICLE IS NOT ECLIPSED
XMV  .92495608 04 YMV  .25761344 05 ZMV  .17210956 05  XM -.79063071 04 YM  .24108433 04  ZM  .26819580 03
XSV  .18025428 05 YSV  .12618555 05 ZSV  .10734304 05  XS -.16682175 05 YS  .15553632 05  ZS  .67448473 04

12 AUGUST      HR     MIN  - SEC TIME-START  .35136000 07  JULIAN DATE 3720.5000
LAT(DEG)  .31107984 02  LONG(DEG) .13851621 03   V.APO(FPS) .32511680 02  V.PERI(FPS) .39552554 03
ALT(NM)   .10426991 09   APO(NM)   .33293863 09   PERI(NM)    .27363958 08  PERIOD(MIN) .10108654 10
X -.26964088 00  Y  .10738838 01 Z   .66365436 00   XD  -.37862081-06   YD  -.16828623-06 ZD -.10792891-06
R  .12908794 01  A  .10409498 03 D   .30938000 02   V    .42816191-06 BETA  .10577467 03 AZ  .97820257 02
A  .22302732 01  E  .84808947 00 I   .35007038 02 NODE  -.91547778 01    W  -.19200173 03  M -.18062538 00
R  .24448474-03  V  .80324356-04 G  -.83024586-01    S   .26996001 03  SVE  .51463132 02  F  .25036072 03
ELK  .76856496 02 MLK  .90103642 02 SLK  .12829148 03  RM  .27565016 05 RS  .20540945 05          ELLIPSE
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ETA   .14115839 00 ZTA   .39800748 01 RHO   .20384824 05   XP   .22291211 05              VEHICLE IS NOT ECLIPSED
XMV   .49050207 03 YMV   .22796073 05 ZMV   .15489627 05   XM -.68148912 04 YM   .23917217 04   ZM   .76293091 02
XSV   .12917363 05 YSV   .12426859 05 ZSV   .10032214 05   XS -.19241752 05 YS   .12760936 05   ZS   .55337061 04

22 AUGUST        HR     MIN  - SEC TIME-START  .35280000 07  JULIAN DATE 3730.5000
LAT(DEG)   .27264635 02   LONG(DEG) .14793780 03   V.APO(FPS) .32658843 02   V.PERI(FPS) .39570839 03
ALT(NM)    .98546810 08   APO(NM)    .33118302 09   PERI(NM)    .27330238 08   PERIOD(MIN) .10033447 10
X -.59737107 00   Y   .90694874 00 Z    .55593374 00    XD  -.38008467-06   YD  -.22119532-06 ZD -.14378978-06
R  .12200289 01   A   .12337131 03 D    .27108218 02     V   .46267400-06 BETA   .95438433 02 AZ   .10757631 03
A  .22191975 01   E   .84751941 00 I    .35004806 02 NODE  -.91635011 01     W  -.19190448 03   M -.12999958 00
R  .23106608-03   V   .78748112-04 G  -.31909194-01     S   .26989880 03  SVE   .55888334 02   F   .26301354 03
ELK  .59660548 02 MLK  .69941013 02 SLK  .11554856 03  RM  .23868742 05 RS  .16348669 05           ELLIPSE
ETA  .12260115 00 ZTA  .41152840 01 RHO  .16237037 05   XP  .23486530 05            VEHICLE IS NOT ECLIPSED
XMV -.78882095 04 YMV  .18471373 05 ZMV  .12895790 05   XM -.61230455 04 YM  .28009827 04   ZM  .14355811 03
XSV  .72433409 04 YSV  .11665315 05 ZSV  .88731848 04   XS -.21254596 05 YS  .96070406 04   ZS  .41661632 04

1 SEPTEMBER      HR     MIN  - SEC TIME-START  .35424000 07  JULIAN DATE 3740.5000
LAT(DEG)   .19695439 02   LONG(DEG) .15829010 03   V.APO(FPS) .32609496 02   V.PERI(FPS) .39555193 03
ALT(NM)    .98533060 08   APO(NM)    .33184364 09   PERI(NM)    .27354193 08   PERIOD(MIN) .10062198 10
X -.92472809 00   Y   .68258201 00 Z    .40867466 00    XD  -.37415894-06   YD  -.30651420-06 ZD -.20270915-06
R  .12198587 01   A   .14356735 03 D    .19573634 02     V   .52443957-06 BETA   .85164060 02 AZ   .11621749 03
A  .22234349 01   E   .84767663 00 I    .35004222 02 NODE  -.91642311 01     W   .16802945 03   M -.77723503-01
R  .23103384-03   V   .83340619-04 G    .30389549-01     S   .26984129 03  SVE   .54032190 02   F -.75137732 02
ELK  .39774064 02 MLK  .44239495 02 SLK  .93766499 02  RM  .22113058 05 RS  .12056111 05           ELLIPSE
ETA  .84838033-01 ZTA  .42949179 01 RHO  .11688088 05   XP  .26060303 05            VEHICLE IS NOT ECLIPSED
XMV -.15712066 05 YMV  .12557726 05 ZMV  .91881350 04   XM -.59773022 04 YM  .34521398 04   ZM  .39727197 03
XSV  .97033227 03 YSV  .98336824 04 ZSV  .69070227 04   XS -.22659700 05 YS  .61761833 04   ZS  .26783843 04

11 SEPTEMBER     HR     MIN  - SEC TIME-START  .35568000 07  JULIAN DATE 3750.5000
LAT(DEG)   .86789094 01   LONG(DEG) .16860817 03   V.APO(FPS) .32438288 02   V.PERI(FPS) .39565222 03
ALT(NM)    .10406759 09   APO(NM)    .33365038 09   PERI(NM)    .27351789 08   PERIOD(MIN) .10138109 10
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R  .12883749 01   A   .16375114 03 D    .86216819 01     V   .62135037-06 BETA   .80672637 02 AZ   .12150460 03
A  .22346035 01   E   .84845126 00 I    .35003552 02 NODE  -.91587248 01     W   .16802531 03   M -.25627881-01
R  .24401039-03   V   .92364473-04 G    .62468051-01     S   .26980124 03  SVE   .33565351 02   F -.32201776 02
ELK  .17639975 02 MLK  .15047538 02 SLK  .50830179 02  RM  .22944336 05 RS  .85464499 04           ELLIPSE
ETA  .27470760-01 ZTA  .45124472 01 RHO  .59178838 04   XP  .29605466 05            VEHICLE IS NOT ECLIPSED
XMV -.22232492 05 YMV  .42258444 04 ZMV  .37816752 04   XM -.64512502 04 YM  .41340837 04   ZM  .74838794 03
XSV -.52748376 04 YSV  .57919050 04 ZSV  .34163916 04   XS -.23408905 05 YS  .25680231 04   ZS  .11136716 04

21 SEPTEMBER     HR     MIN  - SEC TIME-START  .35712000 07  JULIAN DATE 3760.5000
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X -.13550219 01  Y -.96405875-01 Z  -.93873915-01  XD  -.10701485-08  YD  -.54823477-06 ZD -.33381951-06
R  .13616867 01  A  .18406957 03 D  -.39530741 01   V   .64187067-06 BETA  .84376945 02 AZ  .12113324 03
A  .22201607 01  E  .84747419 00 I   .35006538 02 NODE -.91596727 01   W   .16804685 03  M  .26107669-01
R  .25789521-03  V  .98514955-04 G   .36578111-01   S   .26980791 03  SVE  .85147357 01  F  .32456202 02
ELK  .77567017 01 MLK  .19799399 02 SLK  .13848582 02  RM  .25406838 05 RS  .85555800 04        ELLIPSE
ETA -.35087545-01 ZTA -.15298721 01 RHO  .15712113 04  XP  .31891788 05         VEHICLE IS NOT ECLIPSED
XMV -.24233334 05 YMV -.68832438 04 ZMV -.32975629 04  XM -.75485151 04 YM  .46220574 04  ZM  .10957634 04
XSV -.83021550 04 YSV -.11475624 04 ZSV -.17190903 04  XS -.23479694 05 YS -.11136239 04  ZS -.48270930 03

 1 OCTOBER      HR     MIN  - SEC TIME-START  .35856000 07  JULIAN DATE 3770.5000
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R  .14171938 01  A  .20308025 03 D  -.14376244 02   V   .56548286-06 BETA  .82038066 02 AZ  .11650551 03
A  .22119752 01  E  .84698357 00 I   .35005074 02 NODE -.91637822 01   W   .16798869 03  M  .78581244-01
R  .26840792-03  V  .99611231-04 G   .45052864-01   S   .26985623 03  SVE  .29134918 02  F  .75321232 02
ELK  .28434367 02 MLK  .45706113 02 SLK  .56652076 02  RM  .28452584 05 RS  .12071797 05        ELLIPSE
ETA -.76782204-01 ZTA -.13290751 01 RHO  .81822750 04  XP  .32178619 05         VEHICLE IS NOT ECLIPSED
XMV -.20435827 05 YMV -.17320724 05 ZMV -.95874419 04  XM -.91860491 04 YM  .46979866 04  ZM  .13343190 04
XSV -.67599651 04 YSV -.78581673 04 ZSV -.61871124 04  XS -.22861911 05 YS -.47645705 04  ZS -.20660106 04

11 OCTOBER      HR     MIN  - SEC TIME-START  .36000000 07  JULIAN DATE 3780.5000
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ALT(NM)   .12164893 09  APO(NM)   .33213984 09   PERI(NM)   .27353475 08  PERIOD(MIN) .10074616 10
X -.10697398 01  Y -.90521261 00 Z  -.55169398 00  XD   .25392558-06  YD  -.38714711-06 ZD -.20500728-06
R  .15060277 01  A  .22023786 03 D  -.21489082 02   V   .50634876-06 BETA  .75423635 02 AZ  .11031711 03
A  .22252639 01  E  .84780582 00 I   .35004505 02 NODE -.91644639 01   W   .16805617 03  M  .12963751 00
R  .28523251-03  V  .10173537-03 G   .71767920-01   S   .26990415 03  SVE  .33044883 02  F  .96984472 02
ELK  .46140908 02 MLK  .66000480 02 SLK  .78382238 02  RM  .32302267 05 RS  .16365209 05        ELLIPSE
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XSV -.35236804 04 YSV -.12958878 05 ZSV -.93526067 04  XS -.21566917 05 YS -.82727577 04  ZS -.35872985 04

21 OCTOBER      HR     MIN  - SEC TIME-START  .36144000 07  JULIAN DATE 3790.5000
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X -.83331229 00  Y -.12127713 01 Z  -.71133764 00  XD   .29043748-06  YD  -.32712420-06 ZD -.16663851-06
R  .16343885 01  A  .23550650 03 D  -.25800035 02   V   .46811598-06 BETA  .69075644 02 AZ  .10379628 03
A  .22201311 01  E  .84736508 00 I   .35004395 02 NODE -.91535077 01   W  -.19194014 03  M  .18214902 00
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R  .30954328-03  V  .10687685-03 G   .89624191-01     S   .26994410 03  SVE   .31156949 02  F  .10969985 03
ELK  .60737955 02 MLK  .81697939 02 SLK  .91110271 02  RM  .36609583 05 RS  .20554240 05          ELLIPSE
ETA -.10426633 00 ZTA -.11078673 01 RHO  .17327476 05  XP  .34113326 05           VEHICLE IS NOT ECLIPSED
XMV -.61502861 04 YMV -.31387265 05 ZMV -.17812220 05  XM -.13394937 05 YM  .29418730 04  ZM  .11278955 04
XSV  .86098144 02 YSV -.16911023 05 ZSV -.11682750 05  XS -.19631321 05 YS -.11534368 05  ZS -.50015746 04

31 OCTOBER      HR    MIN  - SEC TIME-START  .36288000 07  JULIAN DATE 3800.5000
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X -.57117756 00  Y -.14732614 01 Z  -.84218844 00   XD  .31501810-06   YD  -.27691742-06 ZD -.13726369-06
R  .17905374 01  A  .24880888 03 D  -.28057350 02   V   .44131732-06 BETA   .64222157 02 AZ  .97700652 02
A  .22158828 01  E  .84735738 00 I   .35006512 02 NODE  -.91693333 01   W   -.19201662 03  M  .23478922 00
R  .33911694-03  V  .11484069-03 G   .95757568-01     S   .26997342 03  SVE   .27606175 02  F  .11829083 03
ELK  .72788913 02 MLK  .94216307 02 SLK  .99611811 02  RM  .40921834 05 RS  .24491582 05          ELLIPSE
ETA -.10435565 00 ZTA -.10707477 01 RHO  .20327231 05  XP  .36654190 05           VEHICLE IS NOT ECLIPSED
XMV  .20829921 04 YMV -.35466625 05 ZMV -.20307048 05  XM -.15479882 05 YM  .91148437 03  ZM  .55363623 03
XSV  .37070422 04 YSV -.20104561 05 ZSV -.13487107 05  XS -.17103932 05 YS -.14450579 05  ZS -.62663053 04

10 NOVEMBER      HR    MIN  - SEC TIME-START  .36432000 07  JULIAN DATE 3810.5000
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X -.29084460 00  Y -.16925007 01 Z  -.94976480 00   XD  .33294689-06   YD  -.23102723-06 ZD -.11225615-06
R  .19624481 01  A  .26024935 03 D  -.28944971 02   V   .42050999-06 BETA   .60943154 02 AZ  .92390024 02
A  .22242259 01  E  .84768382 00 I   .35004660 02 NODE  -.91613527 01   W   -.19193195 03  M  .28527689 00
R  .37167578-03  V  .12485103-03 G   .93717418-01     S   .26999296 03  SVE   .23732249 02  F  .12440274 03
ELK  .82866270 02 MLK  .10455673 03 SLK  .10581492 03  RM  .44907635 05 RS  .28177559 05          ELLIPSE
ETA -.10105773 00 ZTA -.10691883 01 RHO  .22315902 05  XP  .40152752 05           VEHICLE IS NOT ECLIPSED
XMV  .10352637 05 YMV -.37803458 05 ZMV -.21909795 05  XM -.17174356 05 YM -.18889097 04  ZM -.36680518 03
XSV  .72366820 04 YSV -.22770659 05 ZSV -.14936612 05  XS -.14058401 05 YS -.16926708 05  ZS -.73399890 04

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R  .21407986 01  A -.89920992 02 D  -.28966948 02   V   .40279559-06 BETA   .59024906 02 AZ  .87929219 02
A  .22182992 01  E  .84722242 00 I   .35002562 02 NODE  -.91528457 01   W   -.19195697 03  M  .33865911 00
R  .40545427-03  V  .13624536-03 G   .87184045-01     S  -.89994751 02  SVE   .19952143 02  F  .12922906 03
ELK  .91453385 02 MLK  .11334408 03 SLK  .11062319 03  RM  .48333971 05 RS  .31632160 05          ELLIPSE
ETA -.96387631-01 ZTA -.10946415 01 RHO  .23205037 05  XP  .44419590 05           VEHICLE IS NOT ECLIPSED
XMV  .18255880 05 YMV -.33567781 05 ZMV -.22702905 05  XM -.18195303 05 YM -.53627329 04  ZM -.16150811 04
XSV  .10646396 05 YSV -.25042983 05 ZSV -.16127674 05  XS -.10585819 05 YS -.18887631 05  ZS -.81903130 04
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ALT(NM)   .18729538 09  APO(NM)   .33107866 09   PERI(NM)   .27304804 08  PERIOD(MIN) .10027999 10
X  .30441166 00  Y -.20157635 01 Z  -.11047495 01  XD   .35236467-06   YD  -.14368541-06 ZD -.67980169-07
R  .23187153 01  A -.81412334 02 D  -.28453733 02   V   .38655874-06 BETA   .58224071 02 AZ  .84238072 02
A  .22183941 01  E  .84760612 00 I   .35009226 02 NODE  -.91737407 01    W  -.19200690 03  M  .39047959 00
R  .43915062-03  V  .14833920-03 G   .78628874-01   S  -.89987255 02  SVE   .16365393 02  F  .13317782 03
ELK  .98919537 02 MLK  .12094321 03 SLK  .11450491 03  RM  .51045496 05 RS  .34880757 05        ELLIPSE
ETA -.91367491-01 ZTA -.11405651 01 RHO  .22896907 05  XP  .49222815 05          VEHICLE IS NOT ECLIPSED
XMV  .25426071 05 YMV -.37951119 05 ZMV -.22778721 05  XM -.18286138 05 YM -.93283335 04  ZM -.31330234 04
XSV  .13925908 05 YSV -.27010441 05 ZSV -.17122277 05  XS -.67859749 04 YS -.20269011 05  ZS -.87894675 04

 6 DECEMBER      HR     MIN  - SEC TIME-START  .36806400 07  JULIAN DATE 3836.5000
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X  .48754850 00  Y -.20835955 01 Z  -.11367489 01  XD   .35383577-06   YD  -.11805612-06 ZD -.55525926-07
R  .24230707 01  A -.76830091 02 D  -.27978205 02   V   .37712083-06 BETA   .58193720 02 AZ  .82341374 02
A  .22228276 01  E  .84767655 00 I   .35006014 02 NODE  -.91649527 01    W  -.19194907 03  M  .42043123 00
R  .45891490-03  V  .15572479-03 G   .73130047-01   S  -.89984283 02  SVE   .14314052 02  F  .13511906 03
ELK  .10297646 03 MLK  .12502430 03 SLK  .11651118 03  RM  .52288352 05 RS  .36742531 05        ELLIPSE
ETA -.88404244-01 ZTA -.11757631 01 RHO  .22112237 05  XP  .52250892 05          VEHICLE IS NOT ECLIPSED
XMV  .29247686 05 YMV -.37029477 05 ZMV -.22526929 05  XM -.17812304 05 YM -.11840964 05  ZM -.41353574 04
XSV  .15833687 05 YSV -.28071791 05 ZSV -.17643199 05  XS -.43983055 04 YS -.20798649 05  ZS -.90190881 04

 ELAPSED TIME   .0903
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RETURN TO SYSTEM FROM 15256(8)

 2879 LINES OF EXEC OUTPUT.

      END OF JOB. ELAPSED JOB TIME=  8.56 MINUTES.                    15.200
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# APPENDIX C

## SOME ASPECTS OF NUCLEAR WEAPON DETONATION IN A COMET

In Section III of this report, the possibility of comet analysis, using a nuclear weapon and earth-based instrumentation, is discussed briefly. In this technique, the comet is excited by detonation of a nuclear device (delivered to the comet by the booster/spacecraft vehicle with the data-gathering equipment on earth), and the comet becomes a very strong artificial source whose radiations and motions will be measured by extremely sensitive detection equipment located on earth. This is in contrast to the conventional method discussed in the body of this study, in which less sensitive detectors are transported to the vicinity of the (weak) natural cometary source, and the data obtained is transmitted over a great distance back to earth. The nuclear weapon probe possibility has not been considered or analyzed in depth or detail during this study; this appendix is solely for the purpose of displaying some numerical indication of the possibilities for approximation.

The categories in which information is desired are: 1) Physical and magnetic structure, 2) plasma interaction (comet hydromagnetics), and 3) chemical composition. Source indicators of importance for the acquisition of new knowledge in each of these categories can be generated by the detonation of a nuclear weapon internal to the comet. The magnitude of each effect will depend entirely on the energy yield effective for activation of that particular effect, and thus upon the weapon yield itself. If the size is properly selected, the bomb expansion will be contained within the coma envelope and nearly all of the weapon yield, no matter how it is partitioned initially between radiation and mass motion, will go into continuum and line radiation from the excited atoms of bomb debris and comet material. If the yield is much larger and cannot be contained within the comet, then some (perhaps large) fraction of the energy released will dissipate as mass motion (expansion) away from the burst point and the comet. The initial partition of energy is set by characteristics of the nuclear device, and is not considered here. Rather, for simplicity we choose the effective yields arbitrarily for purposes of illustration.

Nucleus. The energy yield of the device could go into vaporization of the icy conglomerate, believed to constitute the nucleus, if the device is detonated at the nucleus. Assuming an effective yield of 1 KT (kiloton) = $4.2 \times 10^{19}$ ergs, we find that $10^{10}$ gm of the nucleus could be vaporized assuming that 100 cal/gm for vaporization. This mass is small compared to the total estimated comet mass of $10^{17}$ to $10^{20}$ gm (Section III) but may be significant compared to the mass of a small (ca. a few km diameter) nucleus. The sudden production of $10^{10}$ gm of gas would lead to a great increase in gas density near the nucleus, over the value of $10^{10}$ atoms/cm$^3$ believed to characterize this region in the normal state during sun passage. If the gas produced expands at $v_1$ km/sec, then $n_1$ atom/cm$^3$ would be reached in a time given by $10^{10} = m_H A \frac{4}{3} \pi (v_1 t)^3 n_1$. For $n_1 = 10^{10}$, $v_1 = 1$ km/sec and $A = 15$ this gives $t \simeq 520$ sec at which time the radius would be $R_1 = 520$ km, quite large compared to the normal dimensions of the nucleus. Such a considerable increase in gas density would yield a very much stronger source of solar-photon-excited resonance radiation within a thousand km or so of the nucleus and thus could allow more highly resolved spectral measurements. If the effective yield were 1 MT (megaton), the increase would be much more striking, possibly all of the nucleus could be vaporized, and the radius to a density of $10^{10}$ atoms/cm$^3$ would be the order of 5000 km.

Of course, the matter of the nucleus is not simply vaporized. Rather, the energetic bomb debris and radiations will raise many atoms to highly excited states, and thus produce strong sources of artificially stimulated decay radiation. The atoms so excited, if not initially in the coma, shortly expand into it, and measurement of the decay radiation spectra could disclose differences in constituency between nucleus and coma. The scale of this effect is indicated by the calculations just given; 1 KT could lead to a 1000 km diameter sphere at density $10^4$ to $10^6$ greater than normal coma densities.

Coma. Consideration of the spacecraft guidance and comet orbit uncertainties indicates it is more reasonable to expect the detonation to occur well out into the coma. In this case, when the bomb is detonated, prompt radiation emitted will interact with the coma gases, stripping them out to some radius, and ionizing out to a greater distance. These radiatively-excited atoms will decay to their ground states by radiative recombination and by three body collisions. The kinetic energy of the system initially resides largely in the bomb debris which moves outward from the burst point. This material is highly ionized and expands against the magnetic field within the comet. As it expands, it also interacts with coma atoms by two-body collisions and by collective effects through hydromagnetic coupling with the magnetic field. As the bomb plasma is slowed down and stopped, its kinetic energy must go into heating and excitation of the coma atoms, and thus must be transformed in part into radiant emission.

For an effective radiative yield of $E_r$ KT and an average (multiple) ionization energy of $\varphi_i$ ev/atom, an ionized sphere of initial radius $R_2$ km will be formed around the burst point, according to $4.2 \times 10^{19} E_r = \frac{4}{3} \pi R_2^3 10^{15} n_2 \varphi_i 1.6 \times 10^{-12}$, where $n_2$ is the density of neutral gas plus natural ions in the coma. Assuming $E_o = 1$ KT, $\varphi_i = 30$ ev/atom, and $n_2 = 10^6$ atoms/cm$^3$, this gives $R_2 \simeq 600$ km. At a distance of 0.1 A.U., this sphere subtends an angle of about 17 arcsec, which should be measurable with fair accuracy. As indicated, measurement of size would provide an immediate estimate of neutral atom density around the burst point within the coma, while spectrographic measurements could be made which would yield good information on the chemical composition of coma gases. The total mass $m_r$ kg involved in this radiative excitation is given by $m_r = m_H A n_2 \frac{4}{3} \pi R_2^3 10^{15} =$

$$m_H A \frac{4.2 \times 10^{19} E_r}{\varphi_i \; 1.6 \times 10^{-12}}$$

and is $m_r \simeq 2.1 \times 10^4$ kg for the above example. Thus, even at $E_r = 1$ KT, the mass excited and available for inspection is the order of 500 times greater than that of the chemical contamination experiments discussed in Section III and Appendix A. If the available yield were 1 MT, the mass involved would be 1000 times larger and the geometric scale of effects increased tenfold.

Now, let us suppose a kinetic yield of $E_k$ KT. Considering only plasma-stopping by magnetic field containment, the stopping radius $R_3$ km in a field of strength B gauss would be given by

$$\frac{4}{3} \pi R_3^3 10^{15} \left(\frac{B^2}{8\pi}\right) = 4.2 \times 10^{19} E_k$$

Assuming $B = 10^{-4}$ gauss this gives $R_3 \simeq 2.9 \times 10^4$ km for $E_k = 1$ KT.

This expansion would develop moderately rapidly with time and could be followed both by optical photography and time-resolved spectroscopy (e.g. moving-film spectrographs). Measurement of the radius/time history could yield information on the magnetic field strength, and spectroscopy (of collisionally excited atoms) again would provide data on density, composition, and distribution of coma gases. Here we see that the size of the expansion is no longer small compared to typical coma dimensions (ca. $10^5$ km) and it is evident that $E_k$ = 1 MT would not be contained magnetically within the coma if the B field strength is that assumed above. At $E_k$ = 1 KT the magnetic containment sphere subtends roughly 14 arcmin (half the size of the moon) at 0.1 AU.

Of course, B field expansion alone will be the stopping mechanism only if the mass density of the coma is so low the mass interacted with in expanding to the B field stopping radius is not large compared to the mass of bomb plasma. For comparison let us take an opposite point of view, ignore work against the B field, and suppose that the expansion is slowed down by simple acquisition and acceleration of mass swept up by the expanding front. Further let us assume, ad hoc, that the expansion effectively stops when the mean radial speed is decreased to $v_r$ km/sec. Then the total mass M taking part in the expansion will be given approximately by $\frac{1}{2} M\ 10^3 v_r^{\ 2}\ 10^{10} = 4.2 \times 10^{19}\ E_k$ for $E_k$ in KT, M in kg, and $v_r$ in km/sec.

Assuming expansion stops when mean thermal speeds of comet atoms of order $v_r \sim 1$ km/sec are reached, then $M \approx 8 \times 10^3$ kg for $E_k$ = 1 KT, roughly comparable to that estimated as contributing to radiative emission for excitation by $E_r \simeq 1$ KT. The size of sphere which can contribute this much mass from coma ions is found from $\frac{4}{3} \pi R_i^{\ 3} n_i A m_H = M$ to be $R_i \simeq 2000$ km for $n_i = 10^4$ ions/cm$^3$ and $A \approx 15$, as before. Again, 1 MT yield would encompass 1000 times as much mass and reach a tenfold greater radius.

The brightness of any of the sources considered, whether from radiative excitation or collisional excitation of mass swept up, will be determined by the rate of decay or recombination of the excited species. This is set by the larger of radiative recombination or three-body collision rates in the coma gas. Careful estimates must be made of these rates in order to determine exact sensitivity required and resolution obtainable in ground based photographic and spectral detection equipment.

Other effects of interest which have not been assessed may include greatly increased cyclotron radiation from the increased number of free electrons due to ionization of the coma gases by bomb radiations and kinetic energy exchange. It is conceivable that sufficiently strong cyclotron radiation signals would be generated to allow detection by earth-based radio telescopes of high resolution and sensitivity, and that by this means another direct measurement of magnetic field strength might be obtained.